THE ENGINEER

A Seven-Day Journal

Institution of Naval Architects Annual Dinner

Nearly 900 naval architects and their guests attended the annual dinner of the Institution of Naval Architects, which was held on Wednesday, April 2nd, in London, and presided over by the president, Viscount Runciman of Doxford. The toast of "The Institution of Naval Architects" was proposed by the Right Honourable J. P. L. Thomas, M.P., the First Lord of the Admiralty, who said he was sure the purposes of the Institution, during the ninety-two years of its existence, had been amply fulfilled in the matter of the advancement of ship design. After reference to the affairs of the Royal Corps of Naval Constructors, the First Lord went on to state that the Admiralty welcomed criticism and said that there would be no weakening of the ties between the Royal Navy and the Institution. Mr. Thomas made brief reference to new methods of propulsion and assured the members that the Government was appreciative of the difficulties of fulfilling orders without sufficient steel. The shipbuilding industry, he said, would receive its fair share. Viscount Runciman replied on behalf of the Institution and expressed satisfaction with Lloyd's statement upon the reliability of welded ships. Remarking upon the long evolution of sea transport, the president asked that developments should not be made too quickly since it was necessary for related facilities to make equal progress, and instanced the increased size of oil tankers, the advantages of which would be lost if dry docks of the necessary size were not available. Although quality must be there to ensure results, costs must be low enough to ensure commercial success. In proposing the toast of "The Guests," Mr. Gilbert J. Innes particularly welcomed those from overseas, who, he said, had a common interest with us in the design of ships. Mr. D. F. Anderson, the vice-president of the Chamber of Shipping of the United Kingdom, in his reply, stressed the important role played by "compromise" in the building of ships and maintained that this British quality was responsible for making us the foremost shipbuilding nation.

Shipping Federation of Canada

In his address given at the recent annual meeting of the Shipping Federation of Canada, Mr. A. L. Lawes, the president, commented upon shipping problems and noted that there was a continued demand for cargo space, a demand which had been strengthened by the stockpiling of materials for defence purposes and the movement of goods linked with economic recovery schemes. Despite high costs, orders for new ships continued to be placed, and this, the president said, indicated that there was no undue pessimism among steamship owners. Port delays caused a large amount of unnecessary expenditure and increased the transport charges, and Mr. Lawes said that the effect of the delays was keenly felt by fast ships, which had been specially designed and built, at high capital cost, for the express purpose of making more voyages per annum. One factor influencing the turn round of ships, he continued, was the provision of adequate port facilities and equipment, and he felt sure that the National Harbours Board would effect the improvements warranted by the demand. The board had carried out a limited programme at the Eastern National Harbours, but more piers and sheds were required to meet the needs of expanding overseas trade. Although the movement of general cargo was maintained, the effect of recent pipe-line developments had reduced the import of petroleum products. Another matter which had been taken up with the Canadian Government, said Mr. Lawes, was the formulation of a long-term policy upon which would depend the future operations of the fleets.

The Association of Supervising Electrical Engineers

The annual dinner and reunion of the Association of Supervising Electrical Engineers was held at the Connaught Rooms, London, W.C.2, on Friday, April 4th. Proposing the toast of "The Electrical Industry," Dr. S. F. Dorey, chief engineer of Lloyd's Register of Shipping, outlined the leading part played by the shipping industry in developing the utilisation of electricity. He recalled that, in 1879, two years before the establishment of the first public lighting system in Great Britain, electric lighting was introduced on board ship when two lamps were installed in the "Mendoza." Then, in 1891, Lloyd's drew up the first rules for the safety of electric fittings in ships. From that time the growth in the use of electricity in ships was remarkable: in 1939 the tonnage of electrically propelled shipping was 500,000 tons, and by 1951 the figure had increased to 5,500,000 tons. Sir John Hacking, president of the Institution of Electrical Engineers, who responded to the toast, paid a tribute to the excellent co-operation between the privately owned electrical manufacturing industry and the publicly owned supply industry, whereby the record total of 1113MW of new generating plant was commissioned in 1951. Turning to the broader problems of the development of the use of electricity, Sir John defended the consumers' right to exercise a free choice among the various methods of domestic heating—and, incidentally, criticised the use of the misnomer "space heating," since the object was to warm human beings, not space. The toast of "The Guests" was ably proposed by Mr. A. G. Ramsey, immediate past-president of the Association, who was occupying the chair in the unavoidable absence of the president, Mr. T. G. N. Haldane. Responding on behalf of the guests, Sir Arthur Fleming recalled some of his early experiences in his first job—that of thirteenth engineer in Deptford power station, where he started with hand firing in the boiler-house, served as a greaser on one of the reciprocating engines, and so graduated to the coveted position of switchboard attendant. Since then, Sir Arthur reflected, less than fifty years of progress had brought wind power and nuclear energy within reach and advances such as these emphasised the growing importance of the education and training of young engineers.

The British Association

At a Press conference in London, on Wednesday afternoon, some preliminary information was given about this year's meeting of the British Association for the Advancement of Science, which is to be held in Belfast from September 3rd to 10th, under the presidency of Professor A. V. Hill, C.H., F.R.S. This will be the fourth occasion on which the Association has visited Belfast for its annual meeting, the first being exactly 100 years ago in 1852. Subsequent meetings in Belfast were in 1874 and 1902. The inaugural meeting this year is to take place in the Whitla Hall, Queen's University, Belfast, on Wednesday evening, September 3rd, when Professor Hill will deliver his presidential address entitled "The Ethical Dilemma of Science." Other special evening discourses during the week include one on Friday, September 5th, by Mr. A. C. Hartley, the immediate past-president of the Institution of Mechanical Engineers. Sir Ben Lockspeiser, F.R.S., is the president this year of Section G, Engineering, and his address, which will be delivered on Friday, September 5th, is to deal with "Progress in Aeronautical Science and Engineering." The programme, as usual, makes provision for a number of visits to works, scientific and educational establishments, and other places of outstanding interest.

The British Radio Component Show

This week there has been held in London the ninth annual exhibition of British components, valves and test gear for the radio, television, electronic and telecommunication industries, organised by the Radio and Electronic Component Manufacturers' Federation. There were over 100 exhibitors displaying the large variety of products which the radio, telecommunications and kindred industries of this country are now turning out. The exhibition certainly demonstrated the dependence of all kinds of radio and electronic equipment upon the reliability of its various components. It is interesting to recall that, prior to the war, this country's imports of radio components were greater than its exports; now the value of radio components exported by Great Britain is approaching £10,000,000 a year. Speaking at the opening of the exhibition on Monday morning last, Sir Robert Renwick, president of the Radio and Electronic Component Manufacturers Federation, said that the growing demands of electronics imposed a heavy burden upon the component industry, both in production and research. The industry, Sir Robert stated, was now producing over 12,000,000 components a week, but it should be remembered that that was not merely mass production; every component had to conform to a rigid specification. In addition, many components were required to survive such arduous performance and endurance tests as to prove them almost indestructible under any conditions of service.

The Melchett Medal

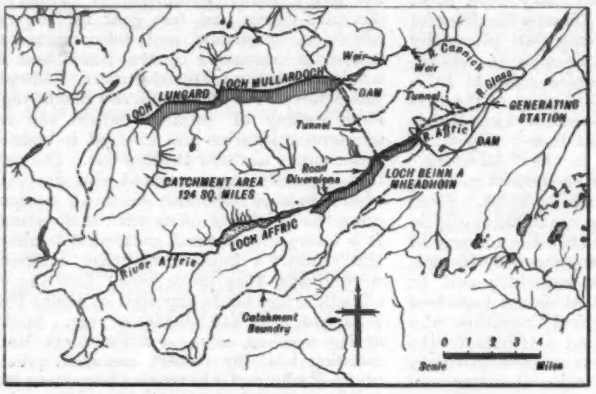
The council of the Institute of Fuel has awarded the Melchett Medal for 1952 to Professor D. T. A. Townend, D.Sc., F.Inst.F., in recognition of his outstanding contributions to the science of combustion, particularly in the field of higher hydrocarbons. Dr. Townend is the Director-General of the British Coal Utilisation Research Association. During the first world war he was in the Royal Naval Air Service, and afterwards went to the Imperial College of Science and Technology, where he collaborated with the late Professor W. A. Bone, F.R.S., and Professor D. M. Newitt, F.R.S., in researches upon gaseous combustion at high pressures. He held successively a Salter's Research Fellowship and a Rockefeller International Research Fellowship. During the early 'thirties, Dr. Townend investigated in particular the part played by "cool flame" reactions in the two-stage combustion process of higher hydrocarbons, complicated phenomena concerned in the spontaneous ignition of hydrocarbon fuels, and "knock" in internal combustion engines. In 1938, he was appointed Livesey Professor of coal gas and fuel industries, with metallurgy, in the University of Leeds, and during the ensuing years achieved a reputation as an administrator, rapidly widening the scope of the research and teaching activities of his department. Early in 1945, Dr. Townend was invited to his present post at a transitional period in the history of the British Coal Utilisation Research Association.

North of Scotland Hydro-Electric Schemes

No. IV—THE MULLARDOCH–FASNAKYLE–AFFRIC PROJECT*

The Mullardoch - Fasnakyle - Affric project is one of the larger of the North of Scotland Hydro-Electric Board's developments. The principal power station at Fasnakyle has an installed capacity of 66MW, and is supplied from a diversion tunnel, including a pressure tunnel, leading from the Benevean reservoir. There is a second and larger reservoir at Mullardoch, each reservoir being formed by a gravity dam. The estimated annual production of the scheme is 236 million kWh. A general description of the scheme is given below, followed by further details of Mullardoch dam.

ONE of the larger of the North of Scotland Hydro-Electric Board's developments, which presents a number of interesting points in both its design and construction, is the Mullardoch–Fasnakyle–Affric project. This scheme is at present approaching completion; it utilises the waters of the rivers Affric and Cannich, both tributaries of the River Glass, and is situated in the counties of Inverness and Ross and Cromarty. It is estimated that about 236 million kWh of electrical energy will be generated annually by the completed scheme.



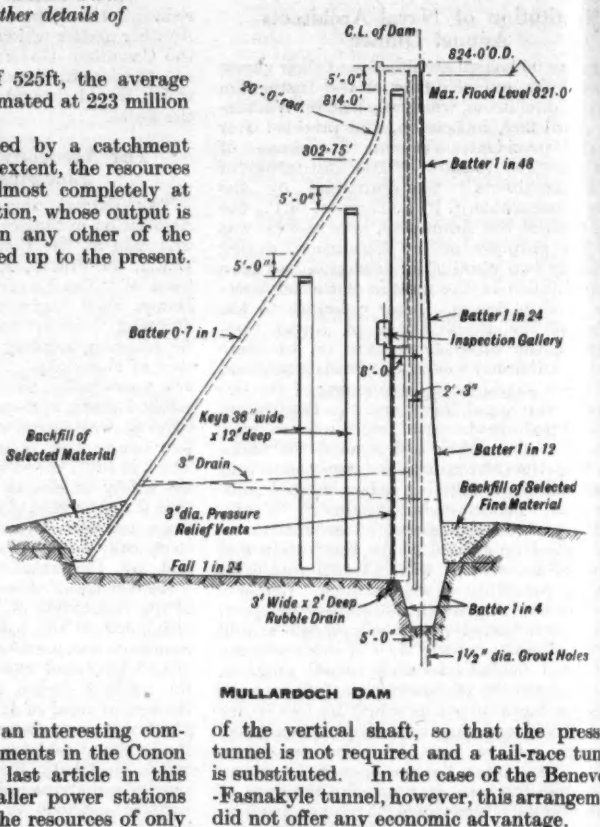
THE MULLARDOCH–FASNAKYLE–AFFRIC SCHEME

The principal works are shown in the accompanying diagram, and consist of two gravity dams, one at the outlet of Loch Mullardoch, on the River Cannich, and one downstream of the outlet of Loch Benevean, on the River Affric. These two dams form reservoirs with useful capacities of 6830 and 796 million cubic feet at crest levels respectively, which are connected by an unlined tunnel 3½ miles long. The top level of the Mullardoch reservoir is higher than that of the Benevean one (817ft A.O.D. against 735ft A.O.D.), so that a small underground power station is under construction at the upstream end of the tunnel, to utilise the head which is available. A single Francis turbo-alternator set of 2·4MW will be installed in this power station to generate about 13·6 million kWh annually.

The intake works of a second tunnel are situated just upstream of the Benevean dam. This tunnel is lined and is 12,340ft long, terminating in a surge shaft and a vertical shaft from which a pressure tunnel with a length of 5024ft leads to the principal power station. Just upstream of the power station, where the rock cover diminishes, the tunnel is replaced by three steel pipe-lines, one supplying each of the three similar Francis turbines. After passing through the turbines, the water is discharged into the River Glass, which runs beside the power station. The three Francis turbines are vertical-axis machines with a total installed capacity of 66MW; they operate under a maximum gross head of 525ft, the average annual output being estimated at 223 million kWh.

The scheme is supplied by a catchment area 124 square miles in extent, the resources of which are utilised almost completely at the one large power station, whose output is substantially larger than any other of the Board's stations envisaged up to the present. The scheme thus makes an interesting comparison with the developments in the Conon basin mentioned in our last article in this series, where several smaller power stations are required to develop the resources of only a slightly larger area. The average rainfall in the catchment is 100in. The accompanying table gives an idea of its hydrology.

One point about the general lay-out of the scheme which is worthy of note is that the more usual arrangement of a tunnel followed by pipe-lines has been replaced by a vertical shaft and pressure tunnel. This method has not been used before in Scottish hydro-electric schemes, but is reflected in later developments, such as the Glen Shira project, and the Errochty section of the Tummel-Garry scheme. One advantage of this arrangement is that of amenity, since pipe-lines are sometimes considered to be an æsthetically objectionable element in a hydro-electric scheme. The pressure tunnel which, in effect, replaces the pipe-lines, is expensive to construct if it needs to be steel-lined, but, on the other hand, the complicated water control gear at the head of a pipe-line—the anti-vacuum valve and automatic valves to close in case of excessive velocity, and so on—can be dispensed with. The logical extension of this system, which has recently been much discussed, is to build the power station underground, at the foot of the vertical shaft, so that the pressure tunnel is not required and a tail-race tunnel is substituted. In the case of the Benevean-Fasnakyle tunnel, however, this arrangement did not offer any economic advantage.



MULLARDOCH DAM

Before proceeding with a detailed description of the scheme, an outline of two previous proposals for the development of the area may be of interest. Both of these proposals were put forward by the Grampian Power Company, the first in 1928 and the second in 1941. The 1928 scheme was rejected by a House of Lords Committee, thus suffering the same fate as all the hydro-electric schemes promoted since 1922 and before the formation of the North of Scotland Hydro-Electric Board. The 1941 scheme was given a favourable report by a Scottish parliamentary committee, but was subsequently rejected by the House of Commons. However, it was the decision to reject this proposal which led to the investigations of the Cooper Committee into the water resources of

Hydrological Data

River	Benevean	Mullardoch	Sidestream Intakes		
	Affric	Cannich	Allt Blar na Gamhna	An Cam Allt	Allt Innis an Droighinn
Area of gathering ground, acres	46,272	31,837	224	1056	499
Average annual rainfall, inches	98·3	107·8	62	66·3	58·2
Average run-off, inches	87·7	97	50	55	47
Average spillage and compensation losses, cusecs	110	17	0·32	1·67	0·67
Average flow available for power, cusecs	375	335	0·97	5·01	2·03
Level of spillweir crest A.O.D., feet	735·0	817·0	787·0	810·0	860·0
Top water level, A.O.D., feet	739·5	821·0	—	—	—
Maximum draw down level, A.O.D., feet	715·0	725·0	—	—	—
Area of reservoir:					
At crest level, acres	1016	2330	—	—	—
At top water level, acres	1069	2402	—	—	—
Capacity of reservoir:					
At crest level, cubic feet	970×10^6	7470×10^6	—	—	—
At top water level, cubic feet	1159×10^6	7860×10^6	—	—	—
Between maximum draw down and crest level, cubic feet	796×10^6	6830×10^6	—	—	—

* No. I, "An Introductory Survey," appeared on July 14, 1950; No. II, "The Loch Sloy Project," on July 21–August 4, 1950; No. III, "The Fannich Project," on June 8–15, 1951.

MULLARDOCH DAM—NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD

the Highlands, and thence to the formation of the North of Scotland Hydro-Electric Board as described in the first article of this series.

One of the criticisms levelled against the 1941 proposal was that the construction of a dam below Loch Benevean would destroy the scenic amenity of the glen, since the level of Loch Benevean would have been raised by 60ft, thus flooding up to the head of Loch Affric. Furthermore, the fluctuation in level caused by the operation of the scheme would have ranged over the entire 60ft. The present scheme has been designed to raise the level of Loch Benevean by 25ft so that the level of Loch Affric is not reached, and to limit the fluctuation in level to a maximum of 10ft (the natural water levels in Loch Affric vary over a range of 10ft). The reservoir is, however, designed to operate down to 715ft A.O D. in an emergency.

Furthermore, compensation water to give a minimum flow of 15 m.g.d. in the River Affric below its junction with the Tomich Burn will be provided, together with a "block guarantee" of 2000 m.g. per year. The required storage capacity necessary for the whole scheme, and necessary to limit the variation in level in Loch Benevean, is obtained in Loch Mullardoch, where the reservoir is correspondingly larger than in the 1941 proposal. A flow of 0·5 m.g.d. of compensation water is allowed from this reservoir. The effect of the modification of the earlier proposals may be gauged from the fact that since the Benevean reservoir was filled last July, the local opinion, and that of the Scottish press, seems to be that the appearance of the loch is much improved, several islets being formed in it and the general effect being undoubtedly picturesque.

Before construction of the permanent works of the Mullardoch–Fasnakyle–Affric project was commenced, extensive preparatory work had to be carried out, including, for instance, the construction of a diesel-driven power station with a total installed capacity of 3600kW, workers' accommodation and extensive access roads. Various diversions of the public roads at the reservoir and power station sites have also been undertaken, and two small weirs built on the river Cannich.

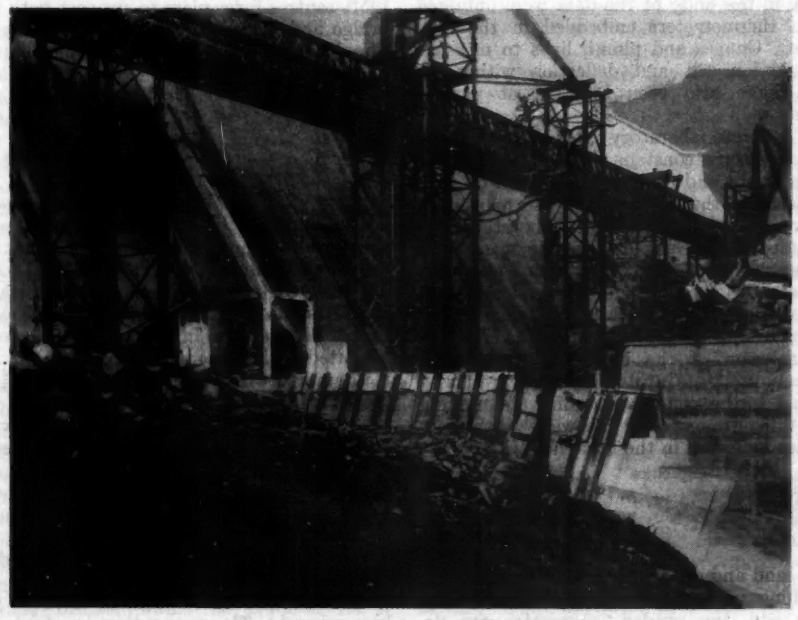
Mullardoch Dam

The Mullardoch dam is shown in cross section in one of the accompanying illustrations. It is 142ft in height at its highest point and is 2385ft long, being built in two wings with a central abutment on an island of high ground, forming the apex of the angle of 140 deg. between the two wings. There is a spillweir 315ft long, with a crest level of 817 A.O.D. on each wing. The total capacity of these spillweirs is 9,500 cusecs.

For emptying the reservoir scour culverts and control gear are installed next to the south wing spillway. These works consist of, first, a 72in diameter scour culvert, and a 72in/60in needle valve, with a free rolling guard gate at the upstream face of the dam, at an invert level of 700 A.O.D. Next to the scour culvert incorporating the needle valve, there is a second culvert also 72in in diameter, which is closed by a sluice gate on the upstream face of the dam, and by a hinged blank flange on the downstream face. This second culvert is not equipped with a needle valve and the gate is operated from a headstock on a platform at 735ft O.D. on the upstream face of the dam, and cannot be opened until the reservoir level falls below the platform, when the water discharged will be under only a small head. The second culvert thus accelerates the final stages of emptying the reser voir and enables it to be kept empty; this second gate is, of course, much more economical than would be a sluice gate opening under the full reservoir head.

The dam is founded on massive psammatic and pelitic schist, excavation for the foundation being taken down to a minimum of 4ft into sound rock. A cut-off trench is provided near the upstream face, pressure grouting in one stage up to a pressure of 100 lb per square inch having been carried out from grout holes spaced along the trench. As a precaution against uplift pressure, a hand-packed rubble drain was built just downstream of the cut-off trench, with pressure relief vents 3in in diameter leading from it to a trench in the inspection gallery and from thence downstream of the dam. Similar vents are provided above the inspection gallery.

The dam has been built in fifty-three blocks, each 45ft long with copper sealing strips between them near the upstream face. The hearting concrete is a 7 : 1 mix, with 375 lb of cement per cubic yard and a maximum aggregate size of 2½in. The



CONCRETING GANTRY—MULLARDOCH DAM

facing concrete is 4 : 1. The temperature rise during concrete emplacement was limited to give a maximum temperature of 100 deg. Fah. in the hearting concrete. In the early stages of construction low heat Portland cement was employed to meet this requirement but owing to an increase in its cost it was decided to replace it by ordinary Portland cement. The temperature was kept below the required limits by control of the temperature of the concrete when placed, and lengthening of the interval between lifts if the placing temperatures were high. The number of blocks was such that the progress of the work was not substantially affected by this measure. The temperatures in the body of the dam were obtained from thermometers embedded in the concrete. Gauges and plumb lines to measure contraction, tilt and deflection within the dam have also been built in at various points.

A concrete laboratory was set up near the dam to keep a constant check on the quality of the work and to give information on such subjects as the temperature rise mentioned above. The work of the laboratory has included the testing of concrete made with larger sizes of aggregate than was first envisaged, up to 4in and 6in maximum.

Coarse aggregates for the concrete are taken from a quarry three quarters of a mile downstream of the dam, and sand from moraine deposits upstream. They are transported to the concrete batching and mixing plant by monocable ropeways with capacities indicated in the table herewith.

Capacities	Tons/hour
Stone ropeway	75
Sand ropeway	40
Sand plant	40
Quarry plant	100

The sand and quarry plants include washing, crushing and screening plant. At the dam site the graded aggregates are deposited in storage piles, from which they are recovered on belt conveyors running in a tunnel under the stocks to the batching plant. The coarse aggregates are batched by volume, but the sand and cement is weighed. Cement is brought in bags by road and is fed on to a drag chain conveyor from the cement store to the batching plant. There are three 1 cubic yard mixers in the concrete station, giving a maximum capacity of 75 cubic yards per hour.

The concrete is discharged from the mixer into skips which are hauled on wagons along jubilee tracks by diesel locomotives to a continuous gantry extending along the downstream side of the dam. The gantry is formed of Bailey bridge units, spanning the north and south outfalls at a deck level of 755 O.D. Steel trestling units at about 135ft centres form piers to support both the bridge and various derricks spaced along it. The blocks of the dam were concreted as follows :—

1–4	Fixed derrick
3–11	Travelling derrick
11–23	Derricks on south gantry
24–28	Derricks on island site
28–37	Derricks on north gantry
38–48	Travelling dock crane
48–51	Fixed derrick
52–53	Excavator rigged as crane

The skips are bottom-dumping, and were developed on the site as it was found that the concrete compacted during the haul and could not easily be removed from the skips which were first used. The concrete is placed in timber shutters in lifts of 4ft and is consolidated with immersion vibrators.

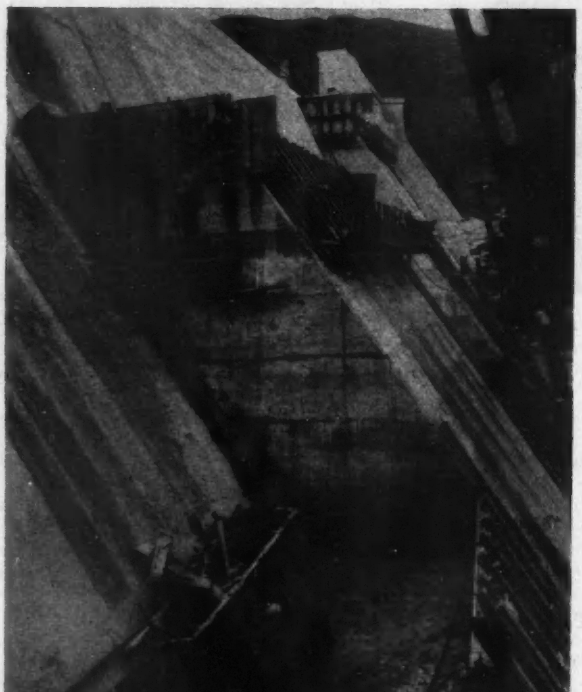
The north wing of the dam was built first, the river being diverted to the south of the island. A gap was left, however, by leaving block 31 low, through which the river was subsequently diverted when construction of the south wing was started, and which was built up when the work was nearing completion.

Construction of the temporary works for the dam was started in August, 1947, and at the present time 260,000 cubic yards out of a total of 280,000 cubic yards of concrete has been placed. The excavation involved the removal of 118,000 cubic yards of material.

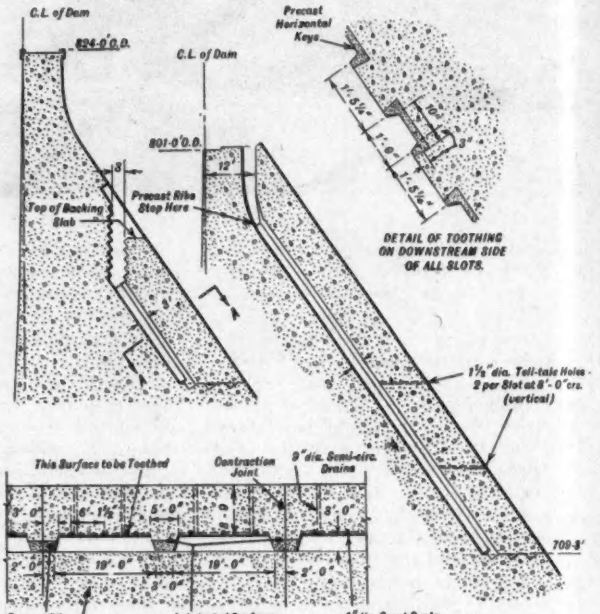
A somewhat unusual problem has presented itself in the placing of the last part of the concrete. During construction economies were introduced in the Board's programme of capital expenditure and it was decided to reduce the height of most of the south wing by 20ft to a level of 797. Subsequently it was found possible to build the structure to its original height. The heightening of a gravity dam is not a simple operation and only a very few instances of such a construction have occurred—the Aswan dam is the example which is brought to mind. In the case of the Mullardoch dam the method adopted is indicated in the accompanying sketch. Each of the blocks affected, which, it will be recalled, was 45ft in length, was first provided with precast ribs placed up the downstream face, as shown. A working space of 3ft was allowed between the old and new work, the interior shutters of the new work being manipulated on skids at their lower end, and with jacks at the top end bearing on the existing downstream face. Apart from under the precast ribs, the existing downstream face of the dam was well scabbled. The new concrete, which was a 4 : 1 mix, was then placed in lifts of 4ft, supported on the previous lift and on the three precast ribs. The joint between the precast rib and the new in-situ work consists of two layers of constructional paper, with grease between, to allow sliding to take place as the new concrete contracts. After sufficient time for contraction has elapsed the 3ft working space will be filled with "prepacked" concrete; the space will be filled with large aggregates and then a colloidal cement grout will be poured in to fill the voids in the aggregate and form the concrete. In this instance the virtue of prepacked concrete is that it sets and matures virtually without shrinkage.

This work was required for fifteen of the blocks on the south wing, but in some cases it was necessary only for a limited height owing to the progress made before the decision to reduce the height was taken. In one or two cases, however, it was necessary for the full height of 120ft.

(To be continued)



HEIGHTENING OF DAM IN PROGRESS


C.L. of Dam
824-0"O.D.
C.L. of Dam
Precast Horizontal Keys
801-0"O.D.
Top of Backing Slab
Precast Ribs Stop Here
DETAIL OF TOOTHING ON DOWNSTREAM SIDE OF ALL SLOTS.
1½" dia. Tell-tale Holes - 2 per Slot at 8'-0" crs. (vertical)
This Surface to be Toothed
Contraction Joint
9" dia. Semi-circ. Drains
709-5'
Precast Ribs
Main Body of Dam
Lubricated Surfaces (2 Layers of building paper separated by 1 layer of grease)
4" dia. Grout Ducts
SECTION A.A.

DETAILS OF METHOD OF HEIGHTENING DAM

The Institute of Metals

No. II—*(Continued from page 476, April 4th)*

AT the annual meeting of the Institute of Metals, the following papers were presented and discussed on March 26, 1952 :—

"Electric Furnaces for the Thermal Treatment of Non-Ferrous Metals and Alloys," C. J. Evans, P. F. Hancock, F. W. Haywood and J. McMullen.

"Gas Equipment for the Thermal Treatment of Non-Ferrous Metals and Alloys," J. F. Waight.

"Batch and Continuous Annealing of Copper and Copper Alloys," Edwin Davis and S. G. Temple.

"Bright Annealing of Nickel and its Alloys," H. J. Hartley and E. J. Bradbury.

"Batch Thermal Treatment of Light Alloys," C. P. Paton.

"Flash Annealing of Light Alloys," R. T. Staples.

"Continuous Heat-Treatment of Aluminium Alloys of the Duralumin Type," Marcel Lamourdedieu.

The President pointed out that this was the fourth symposium in the series on plant and equipment in production processes. The first dealt with casting, the second with hot rolling, the third with cold rolling, and to-day they were to deal with equipment for thermal treatment. It was planned to have a symposium next year on methods of control.

Mr. W. A. Baker (B.N.F.M.R.A.), acted as rapporteur and introduced the seven papers contributed to the symposium.

Discussion

Mr. W. A. Fowler (British Aluminium Company, Ltd.) : I propose to deal mainly with the light alloys, and I would say that the progress which has been made in the development of light alloys, and also in our knowledge of the importance of the various forms of heat-treatment, is evident. There is a growing call for such exacting performance from the furnaces as to tax the ingenuity of the furnace builders, and no doubt to exasperate them from time to time. I should like to confine my remarks mainly to a few examples where there seems to be a real doubt, at least in my own mind, as to what type of furnace is required for a given treatment to give the best all-round results. I shall take as a first instance the heat-treatment of extruded sections. There seem to be two distinct schools of thought on this matter, the one which proclaims the virtues of the vertical furnace and the other which advocates the horizontal furnace. The vertical furnace, we know, is largely standard practice in America and is becoming increasingly popular in this country. In many instances it has superseded the horizontal batch furnace. The horizontal continuous furnace has such protagonists as the Issoire works of the Société Centrale des Alliages Légers. Mr. Paton in his admirable paper claims that the vertical furnace gives a product free from kinks imparted by the supports in the horizontal furnace, but there is a certain amount of distortion when quenching sections of unequal dimensions. He says that the loading and unloading of the furnace are more laborious than for a horizontal furnace, and from knowledge acquired from other sources there is also a doubt as to the temperature control. It seems that the vertical furnace is not all that could be desired in this respect. On the other hand, it has been said that the quenching associated with the horizontal furnace, whether by sprays or by tank immersion, results in such distortion as to make it extremely difficult, if not impossible, to straighten the section by any subsequent treatment. The capital costs involved in the installation of a vertical furnace are very formidable indeed, and the method of loading and unloading is both cumbersome and costly, whereas we know that with a horizontal furnace of the continuous type it is possible to charge direct from the furnace extrusion press, as well as to have a direct discharge of the section either into a spray box or into a quenching tank, and there is little doubt that the capital cost and the operational costs are lower. It may be that each system is superior in its own field of application. If this is the case, I think we should know where the dividing line comes and what factors should influence our choice. If one of these is the degree of distortion imparted to the material on quenching, as has been suggested, then I should have thought it only became important if the distortion is such that it cannot be rectified by any subsequent de-twisting or stretching operation. Mr. Paton suggests that with the horizontal furnace kinks are imparted to the material by the supports which carry it. Presumably these kinks are not easily removed by stretching. In my view, some concentrated attention should be given to the design of the horizontal furnace to remove the cause of this kinking. If the problem could be solved, the advantages in respect of ease of handling and lower capital and operating costs should place it well ahead of its vertical competitor.

My second example deals with the flash-annealing of light alloy sheet, the need for which is well brought out in the paper by Mr. Staples. There are now a number of continuous flash-annealing furnaces for single sheets in operation in this country. The economic disadvantages compared with batch annealing are well recognised and, to my mind, were it not for the fact that a rapid rate of heating in certain materials is essential for metallurgical reasons, it is doubtful whether these furnaces, for the light metal industry at least, would ever have been developed at all. For the same metallurgical reasons as obtain for sheet, it is desirable to apply a flash-anneal to strip in coil form, and no doubt a continuous furnace for this purpose will be available before long. There is some difference of view, however, as to whether, if electricity is used, the heating should be carried out by radiation from electric resistance elements, perhaps assisted by convection, or by induction heating. The furnace builders do not seem to be in agreement amongst themselves on this point. Theoretically, induction heating should possess the important advantage of requiring less space for its installation than equipment using resistance elements. On the other hand, it is clear from the paper by Davis and Temple that a continuous furnace of the electric resistance type has given quite satisfactory results in the annealing of copper strip. It seems from this that one might expect that a furnace of a similar type would be equally satisfactory for light metals. However, to my mind, induction heating is an attractive proposition, not only because of space considerations, but also because of the rapidity with which the strip can be brought to the required temperature.

The paper by Lamourdedieu describes a furnace of this kind for the solution treatment of light alloy strip, but it incorporates a resistance holding zone which is required to maintain the heat-treatment temperature with the required degree of precision. I would ask, therefore, whether such a holding furnace would be required for a flash-annealing process which does not call for the same tolerance in final temperature. I should think, subject to satisfactory conditions being assured on this question of temperature control, and to there being no off-setting disadvantages, induction heating for the continuous annealing of strip should warrant further investigation. It would be interesting to have the views of the furnace builders on this point, particularly on such matters as comparative energy consumption and installation and operation costs. I would say here, as a starting point, that the furnace builders and the electrical engineers should try to reconcile their differences of opinion at the present time on the pros and cons of induction and other forms of heating.

My final example is probably not a very strong one—the furnaces for the solution treatment of strong alloy sheets. Salt baths, both electrically and gas-heated, are discussed in these papers, and so are vertical quenching forced-air-circulation furnaces, both designed for the same purpose. The upper temperature limits to which a salt bath can be worked with safety are well-known, but, as the heat-treatment temperatures for most of the strong alloys are well within the safe range, the two kinds of furnace can, in some respects, at least be regarded as competitive. There are certain metallurgical advantages in the rapid heating achieved in the salt bath, and no doubt for this reason, their retention is more or less assured, but I am particularly struck by the fact that the vertical forced-air furnace has been installed in recent years at large and important centres, among which I would mention the Issoire works of the Société Centrale des Alliages Légers. My company has had experience of both kinds of furnace, and has a fairly good idea of the limitations of both. We realise that the salt bath has fairly high operating costs, but we have not found that the forced air circulation furnace is by any means a cheap unit. Whilst it would be of interest to know the experience of other users in this matter, I suggest that this is another important instance of different kinds of plant being used for the same purpose and that it is the furnace builders who, with their wide experience of diverse conditions, should be able to say which is really the more economic equipment to use.

Other examples on the lines which I have mentioned could be quoted, but I think that sufficient has been said to suggest that, in view of the very large capital costs involved in the installation of modern furnaces, what we require is a comparative study of the various furnaces which are designed to do precisely the same job. This, to my mind, would be of great service to the industry as a whole. If I may throw out a hint to our President, perhaps this Institute might be prepared to sponsor the formation of a panel composed of furnace builders and users to look into the matter further.

A demand has been created for much-improved handling equipment, the cost of which now represents an imposing proportion of the total cost of the complete furnace installation. For instance, for a particular slab pre-heating furnace, the cost of the handling gear was about 30 per cent of the total cost, and an estimate for a continuous flash-annealing furnace for strip showed that the cost of the handling equipment was likely to be of the order of 70 per cent of the total. It is unfortunate that these expensive handling devices are not always accompanied by a reduction in operating costs. This is serious enough, but even where such economies have been effected, they are not so good as they might be, owing to a relatively low pay-load ratio, as it may be called—that is,

the ratio of the weight of the metal to be heated to the total weight of the charge. In the case of a slab pre-heating furnace, although this ratio has progressively improved throughout the years, with the modern pusher-type of furnace the iron carriers or trays still represent about 12½ per cent of the furnace charge. Apart from the heat that they waste, the disposal of the trays involves special gear and additional costs, and in any case is a quite unwelcome additional operation. Fortunately, the heating space utilisable in these furnaces can be very high; otherwise the pay-load ratio would suffer still more.

In the annealing of coiled strip on spools, each spool requires a separate carrier, and this not only reduces the pay-load ratio but also has the effect of reducing the space utilisation factor. In a batch-type box furnace, we found that whereas an output of, say, 2 tons per hour could be achieved with plain coils, when spools and their carriers were used, the output was reduced to about half. The reason is obvious, when it is realised that the spools and carriers form over 20 per cent of the weight of the charge, and the space utilisation was only 65 per cent of that of the plain coils.

Many members of the audience may be wondering what all this is leading up to. I frankly confess that I do not know the answers myself, but it seems obvious to me that many of the present popular forms of heating are thermally very inefficient, and the position, as I see it, is not likely to improve until we are prepared to recognise the fact, and act on it, that heating the furnace structure and the various carriers and conveyors employed at many stages from the initial slab to the final product is a grossly inefficient practice. All the available heat should be directed into the metal itself. Perhaps further consideration of this matter may lead to fresh thoughts, or clarify existing ones, not only on the best forms of heating to achieve this ideal, but on the handling methods and equipment, the cost of which forms an ever-increasing proportion of the total cost of the specialised furnaces of to-day.

The President: Whether a small panel such as Mr. Fowler has suggested can be formed later is, I am sure, a matter which the Council will take into consideration.

Mr. C. P. Paton (Northern Aluminium Company, Ltd., London): Mr. Fowler has raised some very interesting questions with regard to the relative merits of the vertical extrusion and sheet furnace and the horizontal furnace. Perhaps the proof of the pudding is in the eating in this case. In our various works we have a fair assortment of vertical and horizontal furnaces, and with the works operating at less than full capacity now, it is generally the horizontal furnaces which are shut down.

I should like to ask M. Lamourdedieu some questions with regard to his new installation at Issoire. I think that anybody associated with the non-ferrous metals industry must for many years have wished that he had similar equipment and must have speculated on its possibilities, and M. Lamourdedieu is to be congratulated on his enterprise in taking the bull by the horns and trying it out. We have all wondered what happens if, when you are heat-treating sheet, particularly in the thinner gauges, where I gather it it very close to its melting point, you apply tension to it. Do you not run into serious troubles with breakage and distortion in the furnace? What happens when this almost molten strip passes over rolls which are also at a temperature of about 500 deg. Cent.? Is there not serious pick-up and adhesion of metal? Is there any chance that by heat-treating continuously and quenching under tension the strip will come out so flat that subsequent stretching or expensive levelling operations are eliminated? I have observed from his paper that M. Lamourdedieu has obtained speeds of up to about 20ft per minute with the present unit so far. Has he prepared any figures to determine how fast this machine must go in order to be comparable as far as costs are concerned, with the conventional salt bath or vertical air heat-treatment furnace? Some figures which we have prepared on the less ambitious project of annealing have indicated that we must operate it at greater speeds for it to be comparable with the regular batch annealing.

Mr. A. Holden (British Furnaces, Ltd., Chesterfield): There is a point about convection heating which I should like to mention. We have been doing indirect-fired convection heating from a heater external to the furnace, and recirculating. We have been doing that for some time, and in my experience, although the heat transfer rate is considerably higher and the temperature uniformity is better, it is not quite straightforward, in that there is still hot gas radiation which can produce differences in temperature on thin sections. As far as economics is concerned, however, I think that a convection-heated furnace is as economical on fuel as a direct-heated furnace. I do not think that convection heating produces economy of running, and there are other costs, other than fuel, in that the circulation demands heavy h.p. fans, which are a considerable load. Convection heating is not particularly new, but, though it is not new, it is by no means finalised. I do not think that any furnace builder cares to build two furnaces alike, because he usually finds that some improvements on the first can be made in the second. Speaking unofficially for the furnace builders, we would welcome, I think, any panel on which furnace builders and users could get together, as we have done to-day, for free and frank discussion. I do not think that normally furnace builders are particularly frank with each other.

Continuous Heat Treatment

M. Marcel Lamourdedieu (Director, Société Centrale des Alliages Légers, Paris): I agree with Mr. Paton that the vertical form batch furnace is certainly better, or at any rate easier to use, in some cases than the batch horizontal furnace, and certainly we get less distortion with the vertical than with the horizontal furnace. In Issoire, however, we have a horizontal continuous furnace, and that, in my opinion, is far better than both kinds of batch furnace. The handling of shapes is very easy, because they come directly from the extrusion press on to a roller table and to the furnace, and out of the furnace into the quenching equipment, and they come out very straight, and we do not need any stretching on the big sections. On small sections we have not enough experience yet. We have extruded small sections about 3in by 3in, and about ¼in thick, and we had more distortion than on the larger sections, but they were very easy to stretch, and not much work was needed to get a very straight bar.

With regard to the continuous heat-treatment of aluminium alloys, Mr. Paton asks about the difficulty of annealing thin coil. The thinnest coil that we ran on this furnace was 0·5mm, or about 0·02in, and this coil came out very well. The difficulty which we had at the beginning, and which as a matter of fact we still have, is to measure the temperature in the induction coil, but from the tests which we have made we have found that a coil at 500 deg. Cent. can support a tension of about 100 grammes per square millimetre. That is not much, but we can give a certain amount of tension even on thin coil. From the tests which we have made, the coil comes out of the furnace very flat. We have a roller leveller at the end of the furnace, and we have a reel with some tension between the roller leveller and this reel. The coil is very flat, and does not need any further flattening or stretching. The other question is that of marking, and this is certainly the main problem. When we start, with a very good surface on the roll, we do not have any marking, but after some tests have been made, and particularly if we have burnt some coil in the furnace, as we did, we have to clean the rolls again. I do not yet know what will be the best material to use for these rolls. In previous tests on a furnace for continuous heat-treatment the main difficulty lay in the rolls and the handling of the coils through the furnace. That is why we did not succeed in using a convection furnace to heat the coil for the heat-treatment, because we have too long a coil in the furnace to get the right temperature and the synchronisation is not easy.

Mr. Christopher Smith: I should like to raise two points on the question of the present design of furnaces. One thing which appals me is the area that continuous-annealing furnaces take up. The amount of space which they occupy—and space is very expensive in these days—is enormous in relation to the amount of work which they do. I suppose that those of us who use furnaces which heat by the convection of air are appalled at the inefficiency of the heat transfer. Mr. Paton referred to this and asked for faster air speeds inside these furnaces. The material does appear to be heated very slowly in relation to the cost and energy that are being put into the job.

Mr. Ismay (I.C.I., Metals Division): After reading through these papers I formed the impression, rightly or wrongly, that there is a distinct preference in the non-ferrous industry for electrically-heated furnaces. Whilst I do not question this preference as a preference, I do question whether we are justified in installing as many electric furnaces as we do. Electric furnaces are certainly easier to control, and in general require less maintenance; but, although we have progressed a long way from the time when coal and coke were used to heat our metal, coal is still our primary fuel. Gas-fired furnaces have several major advantages which in many cases cannot be offset by easier operation or less maintenance. In the first place, efficient gas-fired furnaces use less coal than electrically-heated furnaces, and this is important not only in the national interest but from the standpoint of manufacturing costs. Secondly, more and more applications nowadays require controlled atmospheres. With electrically-heated furnaces, the cost of providing those atmospheres is a significant item in terms both of heat energy and of monetary cost. As Mr. Waight pointed out, means are now available to control the products of combustion of direct gas fired furnaces, so that a protective atmosphere is obtained without additional cost. Last year I was able to inspect most of the furnaces at one of the largest copper and brass manufacturers in America. Apart from melting furnaces, over 90 per cent of the annealing furnaces were gas-fired. The cost of power and fuel in New England is about the same as in this country, but relative to wages is only about one-third of the price which we pay. One might therefore assume that American manufacturers need be less

concerned with effecting economies than we are. However, the price differential in America between electricity and gas is significant, and is of the same order, about 3 to 1, as in this country. After making these visits, I wondered whether our preference for electric furnaces in the non-ferrous industry was due to our attitude of mind towards them or to the designs of gas-fired furnaces. To my mind, it is a little of both. British gas furnace designers have in the past been slow to exploit the advantages of heating by forced convection, and the result is that a comparison of past experience in many cases showed the electric furnace to be superior from the standpoint of both quality of product and process costs. A comparison of modern designs of both gas and electric furnaces, however, shows that very careful consideration of all sides of the problem is necessary and justified.

I should like to mention the batch furnace versus continuous furnace controversy, and make an appeal for people to consider carefully whether a continuous furnace or semi-continuous furnace can be used. I think that we often tend to say that it is all very well for the Americans, but they have long runs of the same gauge of material and the same alloy. My impression, however, in my four month's visit to the United States, was that in general the Americans handle just as many alloys and just as many small orders as we do, but the proportion of continuous or semi-continuous furnaces in America is significantly higher, with consequent improvement in quality and manpower.

Reduction of Furnace Size

Mr. J. F. Waight (West Midlands Gas Board): The possibility of reducing the size of the furnace for a given output has been mentioned. The size of the furnace to do a given job is ultimately dependent upon the coefficients of heat transfer that can be obtained in the furnace. They are more or less fixed, and where they can be changed they depend, in the case of convection, on raising the velocity of the gas in relation to the charge or alternatively increasing the temperature of the gas with relation to the charge. In the first case that is fairly easy, but it depends on using higher pressure fans, higher velocities and possibly tighter furnaces. If the temperature of the heat-transferring media is increased, it means that a very close control will have to be exercised on the exposure of the work to the heat transfer surfaces; otherwise overheating may result, or undesirable temperature gradients may be produced in the work. An investigation is now being carried on by the gas industry, however, to see how far greater temperature gradients can be applied to work that has to be kept within close limits of final temperature.

Professor Dr. A. von Zeerleder (Zurich): The question of how to reduce the amount of space needed for furnaces is a very important one in actual production and from the point of view of saving production costs. There is, I think, a possibility of using the vertical type of Paternoster furnace as it was developed twenty years ago for billet annealing. For that purpose the weight of the billets became too heavy and so there was a mechanical difficulty in building these furnaces. If you have a chain with platforms on it, going up one side and down the other, you have certain advantages in annealing sheets, for instance. You charge from one side and with electrically-heated furnaces the openings are on the lowest part of the furnace, so that you have a minimum of heat loss and the minimum of space occupied for the maximum volume in the furnace. For soft annealing there is even a possibility of having heat exchange if only the upper part is heated and in the lower part there is heat exchange from the heated pieces to the pieces going into the furnace. On the other hand, for the solution-treating of sheets in the muffle furnace, especially in America, it is standard practice to have the sheets vertical in the furnace. The furnace also blows in the top and there is an opening below, with the quenching tank exactly below, so that the sheets go in the quickest way to the water and there is the minimum heat loss by reason of opening the furnace at the bottom and not at the top. Where the furnace is opened at the top there is a very great heat loss at the moment of opening the furnace.

I always wonder why to melt a ton of aluminium in the induction furnace you have a heat consumption of 450 to 500kWh, while for annealing a ton of sheets at 500 deg. Cent., or for solution-treating them at 500 deg. Cent., or up to 700 deg. Cent., you require between 1000 and 3000kWh, so that much more heat is needed in the heat-treating furnaces than for melting. Of course, the volume of the furnace compared with the tonnage that is in the furnace is much greater in a heat-treating furnace than in a melting furnace, but there is a great deal to be done to the furnace structure to improve the efficiency of the heat-treating furnaces. I should like to ask the furnace builders how they determine the speed of their air circulation in the furnace. We must have in mind that at 500 deg. Cent. the weight of the air is only a quarter of what it is at room temperature, and so the efficiency is only a quarter of what it is at room temperature, so that I should like to know how they determine the speed of air in the furnace. We found that in the kind of furnace to which I have referred the ventilation must go from top to bottom, because when it goes the other way the sheets become damaged. Even when it goes from top to bottom we cannot have more than 5m to 7m of effective speed or the sheets begin to flatten and may be damaged by touching one another. In this kind of furnace, of course, you cannot reverse the ventilation or you damage the sheets.

Mr. H. B. Weeks (de Havilland Company, Ltd.): The particular point that I want to bring forward, with the hope that it is receiving consideration in some quarters and that I may get some useful information, refers to a recent innovation, at least as far as the consumer is concerned. It is referred to as the hot bending of high-strength aluminium alloys. The word "hot" is a little misleading; the reference is to temperatures of 130–140 deg. Cent. Recent experiments which we have confirmed in our own laboratories, have proved that materials such as D.T.D. 363 and 364 are much more readily adjusted at slightly elevated temperatures. It is all very well to bend test-pieces in a laboratory, where you can warm them and have only a foot or two to deal with, but when you have to deal with pieces of production lengths, 12ft or 16ft, the problem of warming them and keeping them warm to carry out the bending operation is another matter. The advantages to be gained, however, are so great that I cannot help feeling that someone may have progressed further than we have in the problem of heating individual pieces to carry out this bending operation, and I mention this problem in the hope that some information may be forthcoming on the subject.

(To be continued)

The Physical Society Exhibition

No. II—*(Concluded from page 465, April 4th)*

THE thirty-sixth Physical Society Exhibition was held at the Imperial College of Science, South Kensington, S.W.7, from Thursday, April 3rd, to Tuesday, April 8th. In this article we describe a further selection of a few of the exhibits that may appeal to engineers.

Mullard, Ltd.

For hydrogen leak testing in large vacuum equipment it is convenient to have the pressure indicating meters as close as possible to the operator so that small transient variations in the indicated pressure may be easily correlated to the position of the hydrogen jet. A vacuum gauge control unit for this duty was shown by Mullard, Ltd., Century House, Shaftesbury Avenue, London, W.C.2. This control unit has been designed for use with 4 and 15MeV travelling wave linear accelerators at present under development at the Mullard research laboratory. As illustrated in Fig. 11, the unit is supported on a low trolley, so that it can be moved to any part of the vacuum system and the meters are mounted on inclined panels so that they are easily readable. Normally the trolley is connected electrically to the gauge heads by a long armoured cable.

Provision is made for the measurement of rough, medium and fine vacuum by means of Pirani, Penning and triode ionisation gauges. In addition the Penning gauge unit incorporates an electronic trip circuit, which can be used to switch off diffusion pump heaters and ionisation gauge filaments if the pressure in the system rises above a preset level.

In using a triode ionisation gauge, the ratio of plate to emission current is taken as a measure of the pressure in the system. In a direct reading instrument it is therefore necessary to adjust one of the currents (usually the emission) to a fixed value immediately before making a reading. Since the emission depends on a number of factors which include pressure, the state of the cathode and the applied filament voltage, it is convenient to use a control circuit to stabilise the emission current.

A saturable reactor provides a simple and economical means of effecting the stabilisation to within ±2 per cent, which is adequate for all normal purposes. The voltage developed across a standard resistor in series with the

FIG. 11—VACUUM GAUGE CONTROL UNIT —MULLARD

gauge head is amplified by a balanced double triode and fed to the control winding of the saturable reactor while the secondary or controlled winding is in series with the gauge filament. A bridge circuit which gives a very sensitive indication of ionisation gauge plate current is provided when hydrogen testing for very small leaks. We learn that the prototype equipment has been in continuous use for the past six months with satisfactory results.

VICKERS-ARMSTRONGS, LTD.

In Fig. 12 we illustrate the harmonic response test gear shown by Vickers-Armstrongs, Ltd., Elswick Works, Newcastle upon Tyne. This instrument was developed to meet the need for a rapid and simple method of obtaining, experimentally, harmonic response curves for a complete servo mechanism and for its component assemblies. It embodies a meter, which gives a direct reading of amplitude response, and a manually operated phase scale, which gives the phase angle, the pointer on this phase scale being arranged to agree with the direction of the vector on a conventional Nyquist diagram.

In principle the instrument is based on the method of Fourier analysis. For example, in the Fourier series $f(\theta)=A_0+A_1 \sin(\theta+\phi)+ \ldots \ldots +A_n \sin(n\theta+\phi_n)+ \ldots$ the coefficient A_1 is found by multiplying the series by $\sin(\theta+\phi_1)$ and taking the average value over a whole number of cycles. The harmonic response test set performs this operation electrically on the signals that are to be analysed.

The harmonic input signal is derived from a resetter Magslip driven by a variable speed motor and wired to a transmitter Magslip, the rotor of which is supplied at 400 c/s and is coupled to a pointer that can be adjusted with respect to a phase scale. Mechanically coupled to the resetter, and rotating with it, is a sine-cosine resolver Magslip and the arrangement is such that the phase relationship between the resolver and the resetter output depends on the position of the phase scale pointer. Potentiometers are provided for input voltage adjustment.

The input, the output and the various sources of electrical signals in the servo mechanism chain are connected to a selector switch. Thence the selected signal is applied through a potentiometer system to an amplifier—via a modulator if required—with a cathode follower output valve, which feeds the rotor coils of the resolver. Both sine and cosine coils of the stator are each coupled to a phase-sensitive rectifier stage with a moving coil meter in the output. Adjustable damping circuits make these meters responsive only to the average values of the output currents over a sensible time period and the effect of frequencies other than the fundamental are eliminated. By turning the phasing Magslip until the cosine meter reads zero the phase angle ϕ and the amplitude A_1 can be read directly. The phasing adjustment can be made automatic by using a servo-motor instead of the cosine meter but this refinement is not incorporated in the instrument exhibited.

In the experience of the manufacturer, test work on automatic positional control has demonstrated the value of the instrument in tuning a system, in diagnosing faults and in the routine checking of components.

ELLIOTT BROTHERS (LONDON), LTD.

The improved automatic dewpoint hygrometer shown by the research laboratories of Elliott Brothers (London), Ltd., Borehamwood, Herts, is an instrument for measuring automatically and continuously the humidity of a gas. The exhibit is in experimental form and incorporates a new technique for thermal control. Our illustrations show the general arrangement of the apparatus (Fig. 13), the optical system (Fig. 14) and the thermal control system (Fig. 15).

Dew or frost formed on a cooled metal surface is detected by a photoelectric system. The metal surface is polished to form a mirror in the optical system (Fig. 14); condenser lenses concentrate the light on to this small area and an image is produced by the objective lens on the disc A. This disc is fitted with a reflector B, so that as long as the polished surface of the detector cell remains clear the whole of the light is reflected from the reflector B and reaches the photocell 2 via the reflector C. When the reflecting surface of the detector cell is obscured by frost or dew the light beam is scattered, so that some light passes behind the disc A and is brought to a focus on photocell 1. In this way the greater the amount of frost or dew on the detecting surface the greater the swing over from photocell 2 to photocell 1.

The photocells 1 and 2 are connected to give "push-pull" output. The optical system for this second photocell is designed to accept the maximum quantity of light scattered by the deposit.

The polished surface is cooled by thermal conduction from a refrigerating system (using solid CO_2 in this instance) and warmed by resistive heating; the heating elements also form the thermal restriction between the body with the polished surface and the cold sink. Thus heat enters and leaves the body through the same paths; therefore in equilibrium there is no heat flowing through the body and uniform surface temperature is ensured. For changing the temperature heat is added or withdrawn through these elements, which are spaced so as to give optimum performance. This arrangement allows the body to be made with small thermal capacity and the heat to be added or withdrawn at a high rate, hence the temperature change can be exceptionally rapid (heating, 30 deg. Cent. per second, cooling 15 deg. Cent. per second was obtained with particular apparatus using liquid nitrogen cooling, but the figures depend merely on the construction). This technique also allows the time lag between application of heat and change in temperature to be very small. Both properties are highly desirable for rapid and precise control of temperature, particularly in an automatic system.

The current required for this heating is induced by a transformer, of which the mirror and connections comprise a single-turn secondary. The detecting surface of the cell is of platinum foil with a copper batton A on the underside. This copper batton forms part of the circuit of a single-turn transformer and is supported by brass strips B_1, B_2 on massive copper bars bolted together at their lower end, which is in contact with the coolant (powdered CO_2). The iron system of the transformer is shown by C, the primary being energised by alternating current from a magnetic amplifier controlled from a stabilised unit connected to the photocells of the optical unit. With no current in the transformer primary heat is conducted via the copper rods and brass supports from the copper batton to the coolant chamber and the temperature of the reflecting surface of the detector cell is cooled. When frost or dew begins to form on this reflecting surface the electrical output from the photocell system is amplified by the magnetic amplifier unit and energises the primary of the transformer. A heavy current then flows in the single-turn secondary circuit, causing heating of the two strips supporting the button. The system operates to keep the reflecting surface of the detector cell at the temperature at which dew or frost just begins to form. The whole system is made to be inherently stable, so that there is no "hunting" of the temperature about the frost point.

The temperature of the surface is measured by a thermocouple connected through an

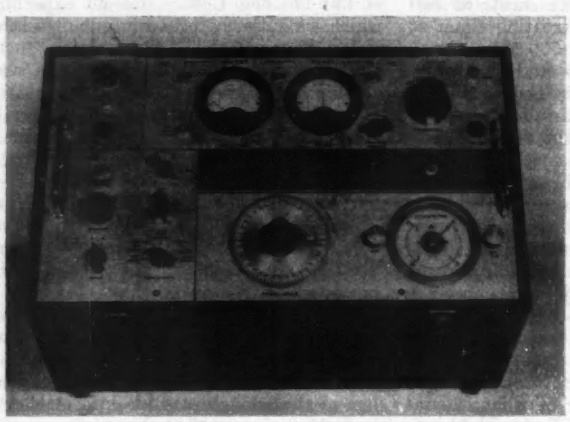


FIG. 12—HARMONIC RESPONSE TEST GEAR—VICKERS-ARMSTRONGS

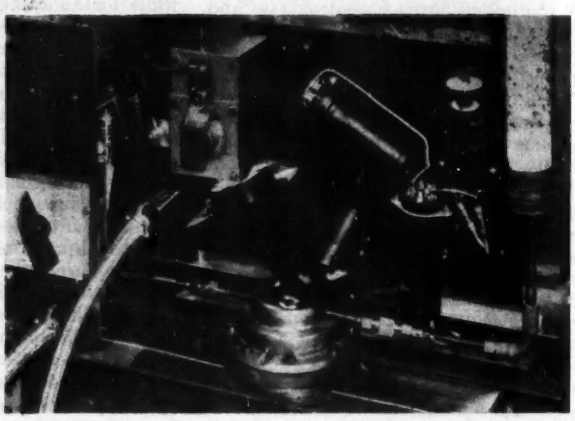


FIG. 13—AUTOMATIC OPTICAL DEWPOINT HYGROMETER—ELLIOTT

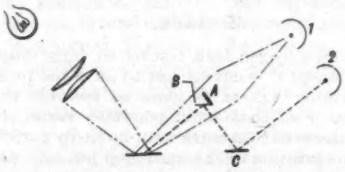


FIG. 14—OPTICAL SYSTEM OF DEWPOINT HYGROMETER—ELLIOTT

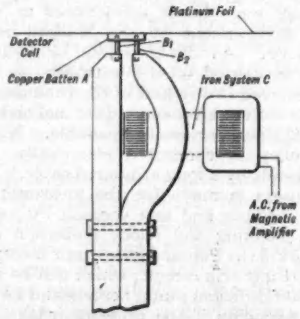


FIG. 15—THERMAL CONTROL SYSTEM OF DEWPOINT HYGROMETER—ELLIOTT

Elliott thermo-couple magnetic amplifier to a panel instrument and recorder. This temperature, which is the dew or frost point, can be related to vapour pressure of water (or other expressions of humidity) from standard tables; a graph showing the relation is on view with the exhibit.

The accuracy of the temperature is limited only by the accuracy of the thermo-couple and the temperature drop in the deposit of frost. Hence high accuracy is possible, as the temperature to be read is steady and the optical system is such as to be able to work on a thin deposit. It is stated that the time of response to a change in humidity is of the order of a few seconds, and that this time increases to ten or twenty seconds at very low frost points (very dry air) owing to the time taken for a deposit to build up.

Shell Refining and Marketing Company, Ltd.

The portable engine indicator (Fig. 16) exhibited by the Shell Refining and Marketing Company, Ltd., St. Helen's Court, Great St. Helens, London, E.C.3, is put forward as an improvement on indicators designed for laboratory or test bed use which do not always combine the compactness, versatility, ease of attachment to the engine and operating simplicity essential for tests in the field. The novelty of the equipment exhibited lies mainly in the application of established techniques to satisfy these requirements. Electromagnetic transducers convert the varying pressures in the fuel, induction or exhaust lines of an engine, or in its cylinders, or the movement of parts such as fuel injection valves, into voltages which are amplified and displayed against a time base on

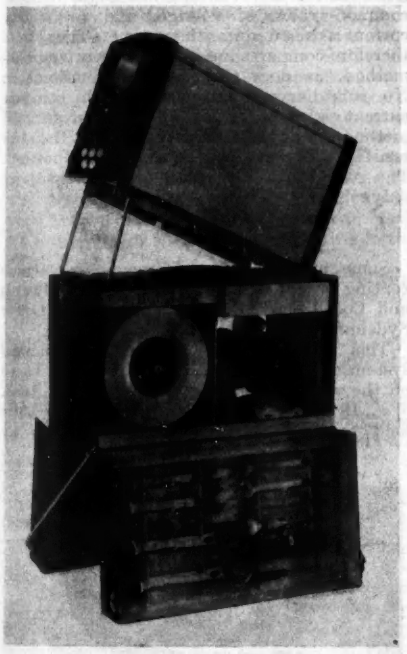


Fig. 16—Portable Engine Indicator—Shell

the screen of a cathode-ray oscilloscope. The time base recurrence is synchronised with rotation of the engine crankshaft by voltage pulses from a rotary generator driven by a rubber pad held against the shaft end. As the orientation of this coupling is inevitably arbitrary, the equipment incorporates a means of enabling the crankshaft position corresponding with any point on the displayed diagram to be determined stroboscopically. This result is achieved by illuminating a scale marked, for example, on the flywheel rim by a portable stroboscopic lamp. The voltage pulses which synchronise the time base also flash this lamp after a manually adjustable electrical delay; simultaneously the cathode beam is momentarily deflected vertically to identify the instant of flashing on the diagram. A full range of accessories is provided, as shown in Fig. 16. Power for the engine indicator can be drawn from either mains or batteries.

National Physical Laboratory (D.S.I.R.)

The stand occupied by the Department of Scientific and Industrial Research is shared by the National Physical Laboratory, the Fuel Research Station, the Joint Fire Research Organisation and the Water Pollution Research Laboratory.

The Electricity Division of the National Physical Laboratory is represented by an attracted disc absolute voltmeter for 500kV.

In this instrument the voltage to be measured is applied between parallel plate electrodes,

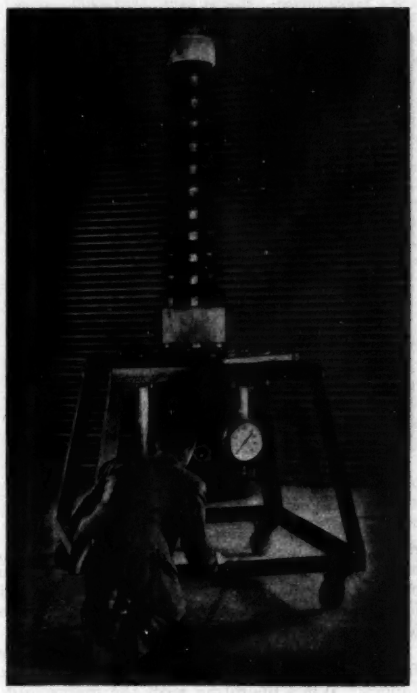


Fig. 17—High Voltage Attracted Disc Electrometer—N.P.L.

one of which is earthed, and the electrostatic attractive force acting on the central portion of the earthed electrode, where the electric field is highly uniform, is measured. From a knowledge of this force and the dimensions of the electrodes, the effective value of the voltage can be calculated.

The electrodes are enclosed in a steel tank, which can withstand an internal gas pressure of 15 atmospheres. In this way it is estimated that a stress of 100kV per centimetre between the electrodes can be attained before sparkover occurs. The lower (earthed) electrode is mounted on three screwed pillars on each of which runs a nut resting, via a thrust bearing, on a base casting. By separate adjustment of these nuts the lower electrode can be brought accurately parallel to the upper and then, by spur gear coupling between the nuts, the separation between the electrodes can be varied from zero to 6 centimetres by means of an internal motor drive.

The central disc on which the force of attraction is measured is carried on elastic supports which can be adjusted so that in its equilibrium position with no voltage applied to the electrodes, it is accurately coplanar with the remainder of the earthed plate, from which it is separated by a narrow annular gap, which allows the disc free movement in a direction perpendicular to its plane. The disc is connected to a coil situated between the poles of a permanent magnet and the upward electrostatic force of attraction on the disc is balanced by a downward electromagnetic force acting on the coil. Lack of balance is detected by a variation of the ratio of the capacitances between a condenser plate carried by the moving system and each of two fixed plates, one situated above and the other below it. Provision is also made for loading the moving system with a 100 gramme weight so that the relation between coil current and force in dynes can be accurately determined at any time.

Owing to the size and weight of the complete instrument, only the earthed electrode assembly and its associated measuring gear were exhibited.

The Aerodynamics Division of the N.P.L. showed a Mach number gauge which is used in controlling a high speed wind tunnel having a variable stagnation pressure. This gauge is a manometric balance designed to give zero deflection at any preset value of the Mach number (which is an explicit function of the ratio of the working section static pressure p to the stagnation pressure H); the readings of the gauge are given independently of variations in stagnation pressure. In the N.P.L. apparatus two balance arms react on each other through a central pivot, the relative position of which can be varied by traversing the whole of one arm. Each arm is set initially so that the moment about its own pivot is directly proportional to the working section static or stagnation pressures respectively.

In operation the position of the moving arm is adjusted to make the effective ratio of the balance arms equal to the value of p/H for the required Mach number. The static pressure is then controlled to maintain balance.

Another exhibit from the Aerodynamics Division is a micromanometer of small capacity. Normally measurements of pressure produced by a fine tube in a reasonably steady air stream are affected by waves created by small variations of speed, which change the mean level of liquid in the manometer. In this new gauge these effects are minimised. The micromanometer consists of a horizontal glass tube of small bore containing a short column of liquid. The tube is mounted on a tilting base and, by rotating a screw thread, the column can always be brought to a fixed position to balance the pressure difference applied to the ends. The meniscus of the column is observed with a microscope. One small division on the wheel measuring the inclination is equivalent to 3×10^{-6}in of water.

Sunvic Controls, Ltd.

A relay designed for use with light contact instruments, such as accurate thermostats, contact thermometers and toluene regulators, was one of the exhibits shown by Sunvic Controls, Ltd., 10, Essex Street, London, W.C.2. Realisation of the inherent accuracy of these instruments depends on the use of contacts having the smallest practical gap and no differential action. The "ED.2" relay is intended to provide positive switching of the load under these conditions, even when vibration is present at the contacts. A thermal

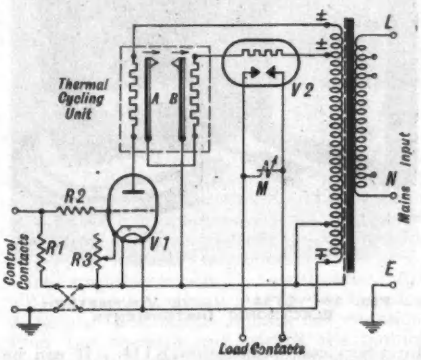


Fig. 18—Electronic Relay—Sunvic Controls

cycling unit is included in the output circuit of the relay. When used in conjunction with a suitable thermostat, proportional control action is obtained, greatly improving the accuracy with which the controlled temperature is maintained.

It will be seen from the circuit diagram (Fig. 18) that the contacts of the sensing element control the bias to the triode valve V_1 in such

a way that the valve conducts when there is a demand for power. The anode load of the valve is a winding on a bimetal element *A* in the thermal cycling unit, which also contains a further bimetal element *B* which moves in the same direction when heated, and both *A* and *B* carry contacts which have a snap action. Thus, when there is a demand for power, the anode current heats the bimental element *A* and the contacts close. This energises the heater on the bimetal element *B* and the winding of the H.V.S. V_8 which closes the load contacts. The heating of the bimetal element *B* tends to reopen the contacts of the thermal cycling unit, reducing the delay when the demand for power is removed and the valve ceases to conduct. This is the operation as an on/off relay when the total delay is of the order of eight seconds.

If the power in the element *A* is between the minimum and maximum values, the thermal cycling unit cycles as an energy regulator, the setting of which is dependent on the value of this power. With vibration at the contacts, the power in the anode load varies from minimum to maximum over a limited temperature range, giving proportional control with this temperature range as the proportional band.

The relay is self-contained and consists of a mains transformer, triode valve, thermal cycling unit and power relay mounted on a metal baseplate together with a terminal block for input and output connections. A "Metrosil" surge suppressor can be fitted when it is desired to control inductive loads. The relay is mounted in a sheet steel case measuring 4¼in by 2¾in by 6¾in. The current in the sensing contacts is approximately 10 microamperes, and the load is 11A at 100/130V and 9A at 200/250V.

ELECTRONIC INSTRUMENTS, LTD.

The valve voltmeter "CT54" (Fig. 19) exhibited by Electronic Instruments, Ltd., Richmond, Surrey, is a development of the company's "Micovac" electronic test meter (Fig. 20), and is intended for use by the fighting and defence Services. It is a compact, strongly built portable instrument designed for active service conditions, and the contrast between it and the commercial version is brought out in our illustrations.

The "CT54" valve voltmeter is a hermetically sealed instrument which complies with the climatic and endurance tests laid down in the

FIG. 19—"CT54" VALVE VOLTMETER—ELECTRONIC INSTRUMENTS

Inter-Services Specification K114. It can be operated from dry batteries or from the mains. An interchangeable mains unit and a battery unit are available and either unit can be fitted in a few minutes.

Measurements can be made of d.c., a.c. and r.f. voltages up to 200 Mc/s. Briefly, the performance characteristics of the instrument are as follows.

On alternating current voltages can be measured up to 480V in six ranges (lowest range 0V to 2·4V). The input impedance is constant on all ranges and at audio and low radio frequencies is equivalent to 7 pF in parallel with a load of 2 megohms. With the probe r.f. measurements can be made up to frequencies of around 200 Mc/s. On direct current, the same voltage specification applies, namely, 0V to 480V in six ranges and voltages of either polarity may be measured. There is an additional 2400V direct current range for which a special e.h.t. multiplier is provided.

Provision is made for balanced voltages to be measured, for example, when measuring frequency modulated discriminator performance. For this purpose the meter has a centre zero scale and balanced voltages from 1·2–0–1·2V to 240–0–240V may be read. The accuracy on direct current voltages on any

FIG. 20—"MICOVAC" TEST METER—ELECTRONIC INSTRUMENTS

range is within ±3 per cent of full-scale reading, and this accuracy is maintained during the entire useful life of the batteries. At audio and low-frequency alternating current voltages the accuracy is of the same order.

There is also a useful ohms scale reading from 0–1000 ohms up to 0–10 megohms in six ranges. When operating with the mains unit, the instrument can be used with supplies of 115V or 230V (nominal), 50 to 60 c/s, and 180V (nominal), 500 c/s. The v.h.f. probe, e.h.t. multiplier and test leads are all housed within the case, and full operating instructions are contained in the lid.

The size of the voltmeter itself is 12¼in by 10in by 5in, and the weight complete is 16 lb. The mains unit is stowed in a transit case which measures 12in by 10in by 6in, and weighs approximately 12 lb.

W. G. PYE AND CO., LTD.

A galvanometer amplifier exhibited by W. G. Pye and Co., Ltd., Cambridge, showed one application of a new device for amplifying small displacements. In this instrument, the moving member carries a pair of small coils lying side by side in the plane of movement. These coils pass through a highly non-uniform magnetic field produced in the gap of a set of laminations energised with alternating current. The coils are connected in opposition, and when they lie centrally in the gap the induced voltages are mutually balanced, giving zero output. On either side of this position a resultant voltage is produced which changes phase on passing through the centre. By amplifying and rectifying with a phase-sensitive detector an output voltage (or current) can be produced which is proportional over a small range to the displacement of the coils.

In the instrument exhibited, this principle is shown applied to the amplification of galvanometer deflections. A 50 c/s energising voltage is used, the output of the pick-up coils is rectified by a phase-sensitive detector, and the rectified output operates a robust indicator. In this way the sensitivity of a freely suspended galvanometer and long light beam is obtained in an instrument no larger than the usual self-contained galvanometer. The ultimate zero stability is governed by vibration of the galvanometer element, but as this element is small and tautly suspended it is much easier to mount than a lamp-and-scale outfit.

Another new instrument shown in laboratory form was the Pye comparator. It makes use of a new principle for comparing two nearly equal voltages, and it illustrates one application of a recently developed mechanical interrupter for the conversion of d.c. into a.c. signals.

Two voltages which have a common point can be directly compared by the usual potentiometer method, but two voltages which do not have a common point are normally compared by relating each to a third voltage. For example, two four-terminal resistors can be compared by passing a current through them in series and comparing the resulting voltages against that derived from a potentiometer. This method necessitates very great stability of two separate currents, and involves repeated and tedious checking.

The comparator principle enables two such voltages to be directly compared. The interrupter is arranged to form a two-pole change-over switch operating at about 50 c/s. The two voltage sources are connected to the fixed poles of the switch; as this is a "break-before make" switch the voltages are never connected together. The moving contacts are connected by a condenser to a valve amplifier. The operation of the interrupter causes each voltage to be connected alternately to the amplifier. When two voltages are unequal an alternating voltage equal to their difference is thus produced and amplified. When the voltages are equal no alternating voltage is ideally produced, and the amplifier gives no output. The sign of the difference is shown by the phase of the resultant alternating voltage. At balance, the condenser charges to the common value of voltage, and no steady current is drawn from either source. The system therefore compares the voltages by a true null-method, as does the normal potentiometer. No subsidiary potentiometer with constant current is required as in the conventional method, and the current through the two resistors (for example) need not be constant. The value of this current effects the sensitivity only.

W. EDWARDS AND CO., LTD.

Some interesting developments in vacuum coating processes were shown by W. Edwards and Co., Ltd., Worsley Bridge Road, Lower Sydenham, London, S.E.26.

This company demonstrated a practical system of sputtering in a magnetic field, based on the work of Penning (*Proc. K. Ned. Akad. Wet.*, 1940, 18, 42), who showed that a magnetic field raises the efficiency of deposition by

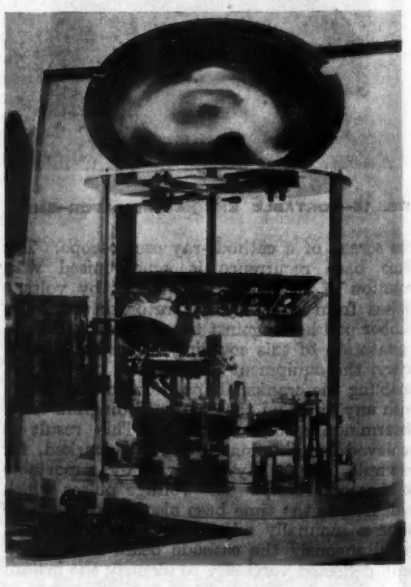


FIG. 21—JIG FOR COATING QUARTZ CRYSTALS—EDWARDS

sputtering. By decreasing the operating pressure the number of collisions between sputtered and gas atoms is reduced so that the sputtered material that would normally return to the cathode is allowed to reach the work surface. Moreover, gas contamination is reduced and the quality of the deposited film is correspondingly improved. In the arrangement demonstrated at the exhibition the heavy steel base-plate of the vacuum chamber and the vacuum-tight door form the pole pieces of a large electromagnet. With the magnetic field in use the normal sputtering discharge pressure of 0·08mm Hg can be reduced to 5×10^{-5}mm Hg.

Another exhibit was a quartz crystal frequency control unit, whereby the frequency adjustment of h.f. crystals can be made directly during the coating cycle instead of by the usual twofold process of sputtering an initial conducting film followed by electroplating for frequency adjustment.

The crystal frequency control unit is illustrated in Fig. 21. Sixteen crystals can be mounted on a motor-driven turret head which can be rotated in a vacuum chamber, so that each crystal is brought, in turn, into the calibration position. The turret is a large Perspex disc with its circumference fitted with spring load connections designed to hold crystals on a standard base. A conical mask with apertures parallel to the surface of each crystal is mounted on the upper surface of the Perspex disc. With this layout a single evaporation from a source mounted near the top of the vacuum chamber is sufficient to deposit a coating about ¼in square on one face of each of the sixteen crystals, a film 0·2μ thick being obtained from a source of about 1g of gold.

Then the remaining face of each crystal is individually coated and the frequency calibration is made. To avoid waste of deposited metal the vapour source is brought near to the crystal face, use being made of four heaters on a second motor-driven turret head which can be seen in Fig. 21, below and to the left of the main turret head. Each of the four positions on the second turret head consists of a molybdenum foil heater bent in an M-shape to carry the gold, so that the vapour is emitted in a smaller solid angle than usual. The crystal electrode mask is a short tubular shield with an aperture in the upper end.

For the measurement of frequency during the evaporation process each crystal makes contact with a pair of spring-loaded contacts mounted under the Perspex holder and wired to an external test oscillator through glass-to-metal seals in the baseplate.

Both the Perspex holder and the vapour source turret head are rotated, as shown in Fig. 21, by a chain and sprocket carried on a vacuum-sealed shaft in the base-plate.

The Telegraph Construction and Maintenance Company, Ltd.

The exhibits of the Telegraph Construction and Maintenance Company, Ltd., Telcon Works, Greenwich, London, S.E.10, exemplified the company's efforts to study the production of alloys and materials which reduce the usage of scarce metals.

Among these materials is "Telconal," an alloy of copper, manganese and aluminium, which has a low temperature coefficient of resistance and is an adequate substitute for the generally employed nickel-copper type of alloy ("Constantan"). Tables of characteristics of "Constantan" and "Telconal" were shown to demonstrate their close similarity. "Telconal" is ductile and can be drawn to fine gauges; it does, however, require treatment for stabilisation, and some care has to be taken to ensure satisfactory soldered joints. "Telconal" wire and strip and examples of their application were shown.

To illustrate the use of the magnetic alloy known as "Radiometal," the company showed typical examples of cores, laminations, and finished parts. Improved refining processes in the production of "Radiometal" allow the material to be made with the following characteristics: initial permeability, 3000–5000; maximum permeability, 50,000–70,000.

The company also showed examples of the use of a high vanadium cobalt-iron alloy which is under development, the retentivity being about 9000 gauss and the coercivity approximately 300 oersteds. This alloy is malleable and can be stamped and pressed in either the hot or cold condition.

Siemens Research Laboratories

A new speed-testing equipment for motor uniselector latch magnets was among the exhibits shown by Siemens Research Laboratories, Woolwich, London, S.E.18.

If they are to function properly, latch magnets used on motor uniselectors must operate with closely specified time limits; they must open the latch contact in not less than 1·2 milliseconds and not more than 1·7 milliseconds after the energising circuit is opened. The speed tester is based on a cathode-ray tube and utilises a circular trace derived from two similar sine waves displaced by 90 deg., the bias condition of the tube being such that the trace is just extinguished when the tester is quiescent. When the circuit of the magnet under test is opened, the resultant change of potential across the winding is applied as a positive signal to the grid of the cathode-ray tube, thus brightening the trace, which darkens again when the signal is removed by the opening of the contact on the magnet assembly.

For the tests of the minimum period, the sine wave has a period of 1·2 milliseconds, and if the release time of the magnet assembly is not less than this, a complete circle is seen on the face of the tube. For tests of maximum lag, the period is 1·7 milliseconds and, providing the release time is less than this, an incomplete circle is visible.

Controls are reduced to press buttons, and the change of frequency and pre-operation of the magnet are effected automatically on depression of the appropriate button. Arrangements are included to open the circuit always at the same point relative to the trace, so that the break in an incomplete circle appears in sensibly the same position on successive operations.

The British Iron and Steel Research Association

Four instruments, two designed for laboratory requirements and two for industrial uses, were shown by the British Iron and Steel Research Association, 11, Park Lane, London, W.1.

One of these exhibits was an electrical manometer designed to measure small differential pressures from 0·001in water gauge upwards, particularly in Pitot tube measurements. In this manometer the sensitive element takes the form of a prestressed copper diaphragm 3·5in diameter, 0·002in thick. This acts as the moving plate in a differential electrical condenser system. Because the deflection of the diaphragm is very small, the instrument has a very quick response even in a small-bore Pitot system. The lightness of the diaphragm also makes the instrument relatively insensitive to tilting. The instrument is to be used in work on open hearth steel furnace design, on aerodynamic models at B.I.S.R.A.'s physics laboratories.

Progress at Crawley New Town

Good progress is now being made with the work of building the new town of Crawley. On March 29th the chairman of the Crawley Development Corporation delivered an address, in which he gave the progress figures for the past twelve months. The first 50 acres of the industrial area have now been laid out, and roads and services installed for a further area of 30 acres. Fifteen factories, with a total floor space of 172,000 square feet are now in production; those under construction total 370,000 square feet. In the various neighbourhoods, a total of 730 houses have been completed, and it is hoped that 1450 new dwellings will be occupied by the end of the year, with an annual rate of 1000 completed each year after that.

The contract for the large reservoir at Weir Wood may now be considered as between one-third and one-half completed. The 4 m.g. reservoir at Turner's Hill is well advanced and the prestressed concrete reservoir at Pease Pottage is in use. The first stage of the sewage treatment works was completed and brought into use last September and 8100 yards of trunk sewers have been laid and are in use. Altogether, just over 30 miles of main and subsidiary sewers and surface water drains have been built.

Since the work started contracts valued at £4,900,000 have been let, works valued at £2,400,000 have been completed and contracts valued at £2,700,000 are at present about to be let. A description of the engineering works involved in building the new town was given in our issue of September 21, 1951.

A Small Compacting Machine

We illustrate below a compacting machine, known as the "Tampactor," designed for work such as the compaction of asphalt, or bituminous or tar macadams. It has been developed by E. P. Allam and Co., Ltd., 45, Great Peter Street, London, S.W.1, and consists of a steel shoe, on which is rigidly mounted a petrol engine, which drives eccentric weights on each side of it. Rotation of the weights causes the shoe to vibrate and travel forward.

The power unit is a 3 h.p. air-cooled petrol engine, the exhaust gases passing through a flexible exhaust pipe and manifold in the base so as to heat the tamping shoe. The tamping weights can be varied to suit different materials and depths of compaction, thus

Small Compacting Machine

giving an impact stroke of between 400 lb and 550 lb. The frequency can also be varied by adjusting the throttle control, but it is stated that better results are usually obtained at the lower frequencies, varying the tamping weights to give the necessary adjustment.

The steel shoe is of welded construction, with a 6½in diameter roller behind its trailing edge. A tubular steel handle isolates the vibrations from the operator and carries the ignition switch and throttle control. The machine is balanced for tamping and it must be tilted slightly to use the roller. One of the advantages claimed for the machine is its adaptability in confined spaces, and the fact that it can be operated right up to walls and curbs.

Oil Well in Nigeria.—At Owerri, 70 miles north of Port Harcourt, in the Niger delta, the exploration well being drilled by the Shell/D'Arcy Development Company of Nigeria is 8600ft deep and there have been shows of gas.

The Institution of Naval Architects

ANNUAL SPRING MEETING

No. I

ON Wednesday, April 2nd, the annual spring meeting of the Institution of Naval Architects was opened in the Headquarters Ship "Wellington" of the Honourable Company of Master Mariners, Victoria Embankment, London, and presided over by Viscount Runciman of Doxford.

In the annual report of the Council it was recorded that Sir Stanley V. Goodall, K.C.B., O.B.E., and the late Sir Amos Ayre, K.B.E., had been elected as Honorary Vice-Presidents, and that Vice-Admiral E. L. Cochrane, K.B.E., D.S.M., D.Eng., LL.D., U.S.N., had been made an Honorary Member. The membership continued to increase and the accounts, presented by the treasurer, indicated that the financial position had been maintained.

The Gold Medal of the Institution was awarded to Messrs. Mark L. Ireland, H. W. Semar, and N. L. Mochel for their joint paper "Higher Steam Conditions for Ships' Machinery," presented during the London proceedings of the International Conference of Naval Architects and Marine Engineers, held last year. It was stated that a senior member of the Institution would present the medal at a meeting of the Society of Naval Architects and Marine Engineers, New York, later in the year.

The Premiums for 1951 were awarded to Professor C. W. Prohaska for his paper "Influence of Ship Form on Transverse Stability," read before the spring meetings; and to Mr. J. C. Neidermair for his paper "Ship Motions," given before the International Conference of Naval Architects and Marine Engineers.

The 1951 Samuel Baxter Prize was awarded to Mr. H. E. Skinner, O.B.E., for his paper "The Safety of Small Ships," and Mr. T. N. Stephens, of the Royal Technical College, Glasgow, was awarded the Duke of Northumberland Prize, a special prize being presented to Mr. R. S. Young, of Birkenhead Technical College.

Notes upon the research work carried out by the Ship Division, National Physical Laboratory, the British Shipbuilding Research Association, Pametrada, and the British Welding Research Association were included in the report, and also the results of the 1951 scholarship examinations, together with a list of the scholarship offered for competition in 1952.

The president made a presentation, on behalf of the members, to Mr. P. J. Shilham, who retired as assistant secretary of the Institution at the end of 1951.

Viscount Runciman of Doxford then gave his presidential address, abstracts from which are printed below.

This is the first occasion on which I have had the privilege of addressing a general meeting of the Institution as your president, and I am sensible of the honour you did me in choosing me to follow so distinguished a line of holders of this office. I did undergo a trial trip last summer at the International Conference of Naval Architects and Marine Engineers because of the ill-health of my distinguished predecessor. We are glad to see in his increasing public activities evidence that Lord Cunningham is regaining his wonted vigour.

The International Conference provided not only useful contacts with those in other lands who pursue similar objects to our own, but was the occasion of papers and discussions of lasting value.

In the international field we have welcomed an invitation from the Associazione Italiana di Tecnica Navale for joint meetings in Genoa, Rome and Naples in September. The Council feels that this meeting offers a suitable opportunity to elect General G. Rota an honorary member of the Institution. Though not so well known to the younger generation, senior members will be aware of the valuable contributions to naval architecture which have been made in the past by this distinguished Italian constructor, who is in every way worthy of the honour it is now proposed to confer on him. It is proposed to make the presentation of the Diploma of Honorary Membership in Rome during the autumn meetings.

Experience has shown that the big revision of the by-laws and regulations which came into force in 1948 left one or two points still in doubt. Accordingly, the Council has set up a small committee to consider them and remove the possibility of misinterpretation. It is planned to complete the work during the next few months, and to call a special meeting in the autumn to approve the proposals.

The Institution's library is engaging particular attention, and it is now being overhauled and re-catalogued. We want to provide the books which members need, but must avoid duplication of volumes which are more appropriately to be found elsewhere. Equally we must not fill the library with technical books seldom required and of only limited value to naval architects. This does not mean that suggestions from members for new books are unwelcome, but it does mean that the choice of them must be made with unceasing care.

We have for some time been looking forward to having our own lecture hall. I am sorry to say that, despite the efforts, backed up at the highest levels, we have failed to secure a licence to build. This is probably inevitable at the present time, though, so far as steel is concerned, the new building only requires 3½ tons! All the plans are prepared, and the approval of all the London authorities concerned has been received. As soon as permission to build is given we shall go ahead and provide a proper home for ourselves, with much improved facilities for our members and for holding meetings, which might then be held more frequently.

We start off to-day and to-morrow morning with three papers of wide general interest, and to-morrow afternoon we have two important papers of considerable interest to the Institute of Marine Engineers. Finally, on Friday we offer a selection of four different subjects, all of them of importance to naval architects.

Members of this Institution are naturally familiar with the effect of the re-armament programme on shipbuilding; it gives rise to severe practical difficulties in things like the shortage of steel and of certain sorts of specialised labour, though on the professional side it stimulates the designer, particularly of warships, and results in such interesting types as the aircraft carrier "Eagle" and the "Daring" class of destroyers. It should stimulate also metallurgical and other researches into the possibilities of more economical materials and ways of using them, which could be of benefit far beyond the production of warships. It is recognised, for example, that warships, being required to withstand abnormally high working stresses, including shock stresses, and to be capable of operating at very low temperatures, call for steel of good notch ductility. There is increasing experimental evidence that British steels vary considerably in this respect, and there is an urgent need for a simple test for discriminating between those which are acceptable and those which are not. This is primarily an Admiralty requirement, as is the need for developing a satisfactory technique for welding aluminium alloys, but merchant ship design and construction would benefit if those problems were satisfactorily solved.

Of quite a different kind is a research into the most appropriate way of measuring the tonnage of merchant ships. This is a subject which bristles with difficulties far beyond that of arriving at a good simple mathematical answer. The existing terms of gross and net tonnage are embodied in Acts of Parliament and are the basis upon which the ship is made to pay for the services she needs. It has become apparent that in some respects, notably propelling power allowances, the existing laws are out of date and have begun to militate against good and economical design in certain kinds of ship. As main engines become more compact for any given horsepower, the defects of the existing rules will become more serious, and I am glad that some steps are being taken to amend them. It is particularly satisfactory that in this country shipowners, shipbuilders, the technical institutions, and Lloyd's Register should be working together on this question in which all our interests are basically the same, but any reforms to be effective require international agreement, and for that reason considerable discretion is desirable in any public discussion of the subject.

The more we are able to develop and co-ordinate our working relationship with the kindred institutions and other bodies concerned with the production of better ships so that each one of us is complementary to the others, the more useful we shall be. We shall never design the perfect ship, or even the most efficient compromise, but year by year we progress towards that end.

The first paper presented at the spring meeting of the Institution of Naval Architects on Wednesday morning, April 2nd, was:

BRITAIN'S DEEP SEA LINER TRADE, 1945–1951, AND SOME RANDOM THOUGHTS

By Basil Sanderson, M.C.

Summary

The paper is largely a continuation of that given before the Institution by Mr. Walter Warwick in 1944. The tonnage by nationality for the years 1939, 1949 and 1950, and the percentage of world tonnage owned in the United Kingdom covering the years 1905 to 1950 are given in two tables, while another table indicates the make-up of the home fleet. The two problems facing liner companies are stated and that of making good war losses is briefly discussed, while that of replacing obsolescent vessels is more widely reviewed. Taxation, wear and tear allowances and the difficulties of bridging the gap between initial cost and the cost of a new ship are examined. Further points dealt

with in the paper are the influence of other forms of travel and the need to improve the insulating medium in refrigerated ships to reduce loss of space.

Discussion

Mr. John Baird: With regard to the loading of a ship and the wasteful exercise of the lift, there are ships in existence which have in the superstructure the means of horizontal loading. In a train ferry it is the obvious thing to do, but in the general cargo carrier it can only waste space.

This question of the hangar berth is tied up to some extent with the loading of the ship, and I feel that the cargo lifting machinery is in the wrong place. Why not give us tiered warehouses alongside, having the hold cargo at the top and 'tween deck cargo at the bottom, gantry cranes being provided for loading the whole ship? In that case the cargo to be loaded is lifted already to the necessary height, so that no time is wasted and dock machinery is unnecessary.

In the liner trade there has been a succession of very similar ships, each fitted with deck machinery, only intermittently used, and generators to drive the machinery, the fuel for which is carried halfway around the world. If there is any possibility of the port being modernised as well as the ship, surely that is a way in which the shipowner can make a considerable saving.

A refrigerating plant is composed of two parts: the refrigerating equipment itself and the insulation. If you devote time to improving the machinery you are improving the equipment as a whole. The real problem for the refrigerating engineer is to preserve a balance between the amount of insulation he uses and the amount of machinery he puts in.

Mr. J. L. Kent: Liners used mainly for pleasure cruises need large expanses of deck area, and a departure from the conventional ship form to that proposed a few years ago might receive consideration.

The proposal was to build a ship with several decks, rectangular in shape and supported above the water surface upon two parallel horizontal cylinders with shaped ends, containing the propelling machinery, fuel, stores, &c. It was shown that such a ship could be made sufficiently stable and strong, and that it could be driven at the same speed as the equivalent conventional ship with approximately the same expenditure of power.

The author notes that the latest hull forms, when new and clean, often give startlingly good results in speed and fuel consumption, which are lost when the hull becomes fouled. This statement supports my view that laminar flow is present in the friction belts of many modern full-sized ships of moderate speed, and that Reynolds number (defined as ship's length times its speed) is not a criterion of the presence or absence of such flow. If true, then turbulence stimulation should not be used in model experiment work, as it masks the possibility of a ship form inducing laminar flow. For the full-sized vessel such a flow is not an objection, as the shipowner profits at least during the first voyage out of dock; but the margin of power allowed should cover the possibility of a fouled ship on the second and subsequent voyages.

Professor E. V. Telfer: With regard to the increase of 25 per cent in fuel consumption due to fouling, I find that the average of my pre-war figures for fouling in Australian waters is 8 to 10 per cent. Some of my recent work showed that it is possible to calculate the extra resistance due to point or sharp roughness, and that the increase in the resistance and the power required was a function of the height of the roughness and also a function of the density of the roughness. A small density of roughness, such as 5 per cent of the whole surface covered by that roughness, can increase the resistance by 20 per cent of the total resistance possible if the whole surface were covered by that roughness. We are now finding that, although a ship has a little shell, it can increase her resistance by as much as 20 to 25 per cent, and if the density of roughness goes up to 50 per cent, i.e., only half the surface is covered by this particular type of roughness, that is as bad as if the whole surface were covered. A barnacle of the order of 1¼in could easily produce 100 per cent increase in the resistance of the hull.

The other point is whether the modern streamlined ship, and presumably the welded ship, is more sensitive to fouling than is the pre-war ship. I think it is. Suppose the modern ship is 20 per cent better intrinsically than the pre-war ship, so that if the pre-war ship had a consumption represented by 100, the new ship has a consumption represented by 80. If the resistance caused by fouling is the same in both cases, and is 20 per cent of the 100, then 20 in 80 represents 25 per cent for the new ship in terms of increased fuel consumption, so that the modern ship must suffer more than the old.

Some support for a still further penalty in the case of the new ship is obtained by a study of work on the frictional resistance of long pontoons. Those pontoons were towed in the Hamburg tank and were 250ft long, so that they were not models, but a particularly narrow type of ship. The pontoons were tested with smooth surfaces, and then with ordinary riveted construction with fore-and-aft seams. Butts were introduced on both types. When applied to the smooth pontoon the butts increased the resistance by 16 per cent. Riveted construction increased the resistance over that of the smooth pontoon without butts by 16 per cent, and the addition of butts to the riveted construction caused no further increase. The existing roughness in the form of rivets and seams swallowed up the resistance due to the butts.

Therefore the pre-war plated ship, having a natural structural roughness, can withstand a certain amount of fouling without showing any marked increase of total resistance, whereas the completely new surface, having no such natural roughness, must immediately show the effect of any fouling.

Dr. J. F. Allan: The percentage quoted in the paragraph on fouling may appear rather alarming, but we can get similar figures from other evidence. The effect of the fouling is almost entirely a matter of increasing the frictional resistance; we may have improved the modern ship as regards wave making, but that is not much influenced by fouling.

If we assume that pre-war ships were fouled to the extent discussed, modern ships, so far as friction is concerned, are reduced to a par. We have an increase of fuel consumption in the modern ship of 25 per cent due to fouling, and of 8 to 10 per cent for the pre-war ship. Calculated differentially, the modern ship is initially some 15 per cent better than the pre-war ship, and that is an interesting conclusion, increasingly supported by evidence from other investigations.

I do not think it is a practical policy to study the effects of roughness and fouling on the model scale. If the modern ship with the flush-welded hull is 15 to 20 per cent better than the pre-war ship with the all-riveted hull, we have to find a method of keeping the modern ship clean, and it means that the basic smooth friction is much lower than we thought it was from Froude data which we have been using for the last fifty or sixty years.

Sir Ronald T. Garrett: The picture of the state of British shipping is not very encouraging. Although our total tonnage is back to what it was in 1939, the 1939 tonnage was some 10 per cent less than it was in 1930, in spite of the fact that world tonnage had been increasing during those years. Of the world tonnage launched during the year 1951, we had almost exactly 20 per cent for registration in this country, so that we are barely keeping our place. The sum of the liner and tramp tonnage is substantially less now than it was in 1939, and we have maintained the overall tonnage only by the increase in the tanker tonnage.

I suggest that the increase in the volume of travel has been due to the increase of population and the much higher standard of living, and I agree that travel creates travel. There is still room for the passenger ship in competition with air, subject to the passenger shipowners being able to compete in the matter of fares with State-subsidised air services, and that they will be able to make ship travel more comfortable than travel air.

Mr. H. F. Sherborne: May I mention another aspect of fouling which shipowners will hear more about before very long? Harbours and estuaries are becoming fouler, and ships are tending to remain in them longer, and as a result corrosion is arising in places where we had thought we had the problem completely solved.

Dr. S. F. Dorey: In my opinion the problem of fouling and increased resistance is not so much a question of the lines of the ship, but is one of the preparation and protection of the hull, and it is on those lines that we have to direct our research.

Mention should be made of the experiments which have already been published on the use of cathodic protection, by which it should be possible not only to protect the hull from corrosion, but to shed this fouling by means of an applied current. By adjustment of cathodic protection and an applied burst of current when in harbour it will be possible to shed all the fouling and start again with a comparatively fresh surface.

Dr. J. Tutin: The first thing we have to do with regard to the fouling problem is to discover Nature's method of dealing with it, because the creatures which foul ships do not adhere to any fish. If we can solve that problem it may lead to new types of anti-fouling paints which will contain the material which protects fishes and whales.

The President—Viscount Runciman: We were established to promote the improvement of ships, and I cannot think of anything which is militating more against the improvement of ships than the increased difficulties in building them, of which taxation is the chief.

The liner owner has to keep his fleet in being to maintain his traffic, and that means that he must order ships more or less continuously, so that over a period of rising costs there would be a certain spread. I think many tramp owners hoped that prices would fall, but with prices rising they have become discouraged. Perhaps if prices stabilise there may be a considerable amount of tramp ship building as soon as berths are available. Tankers are to some extent taking the place of tramps, since we are bringing oil into this country instead of taking coal out of it. The tramp tonnage in this country is getting dangerously low, and at the present rate of replacement of liners and tramps we shall find about ten years hence that the dry cargo mercantile marine of this country is down by nearly one-sixth.

(To be continued)

Training and Welfare at Thorncliffe

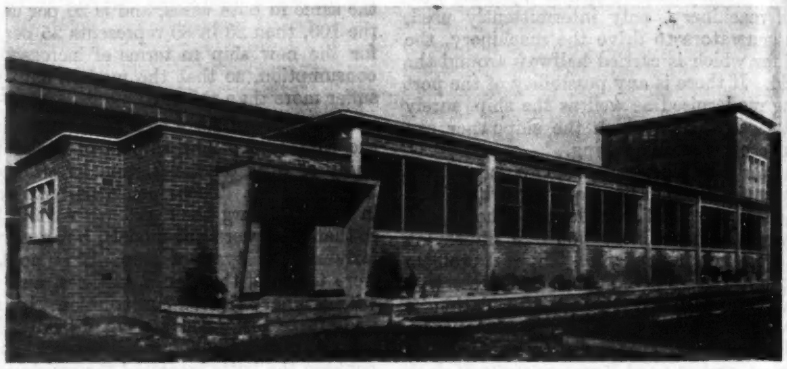
LAST Friday, April 4th, the Minister of Labour, Sir Walter Monckton, Q.C., visited Thorncliffe, Sheffield, to open the new foundry baths and an extension to the apprentice training school which have just been completed at the works of Newton Chambers and Co., Ltd. This firm, it may be recalled, engages in many varied activities. Its heavy constructional division is concerned primarily with the production of plant for gas works, steel and chemical works, whilst its light castings department concentrates on equipment needed for heating, cooking and other domestic appliances. Other departments in the organisation include a "mobile engineering" section, which turns out excavating machinery, and an extensive chemical works. The company employs about 4000 people at Thorncliffe, and for many years has expended a great deal of thought, time and money upon the maintenance and continual improvement of its training and welfare schemes.

Following the recommendations made in the Garrett committee's report on foundry conditions, the company decided upon the provision of up-to-date bathing facilities for its foundry workers, and early last year was granted a licence to proceed with the scheme. It had already been decided that the most suitable site for the baths was a triangular area adjoining the main foundry building, which was used for stacking semi-finished products of the heavy construction division. This involved the selection of an alternative site for stacking those products, and the one selected had to be cleared and equipped with a large overhead crane, an operation which was completed by March, 1951, when work on the baths project was started. The baths were designed by Husband and Co., architects and consulting engineers, of Sheffield, the principal contractor for the scheme being R. S. Hutchinson and Co., Ltd., Sheffield. The main building, which houses the baths, is 91ft long, 50ft wide and 11ft 6in high. It is supported by reinforced concrete columns and has a reinforced concrete roof, the whole structure having been designed to allow for the addition of a second storey. At the north-east end of this building there has been constructed a tower containing on the ground floor the calorifier chamber and on the first floor the "Plenum" heating system chamber. On both floors, there is sufficient space to allow for the plant to be doubled. The baths building has three main divisions, namely, the working clothes locker room, the main baths, and the clean clothes locker room. Men coming in from the foundry leave their dirty working clothes in the first locker room, proceed to the showers, and thence to the second locker room, where they put on their clean clothing. On arrival at work, they place their outdoor clothes in the "clean" lockers, change into their working clothes and proceed to the foundry. A separate room in the building is fitted with basins for hand washing. The floors and walls of the bathrooms are hygienically tiled, and the ceilings are treated with granulated cork to reduce condensation. The locker rooms have asphalt floors, with drainage channels for washing down, and the lockers themselves have been arranged to make the best possible use of space. An accompanying illustration shows the main baths building.

The apprentice training centre—which is adjacent to the firm's business training school—now consists of a main central block and two wooden buildings around a quadrangle. In addition to reception rooms and administrative offices, the main building includes a gymnasium, a foundry training section, a laboratory, classrooms, and changing rooms equipped with showers. The wooden buildings house a number of classrooms, a machine shop—part of which is illustrated herewith—a constructional steelwork shop and a welding bay. The foundry apprentices have their own cupola for melting metal, their own mechanical sand-mixing, fettling and core-drying equipment, and their own sand-testing laboratory. The small cupola, which was built by apprentices in the constructional engineering section of the works, is installed in a special annexe. In the machine shop full use has been made of colour, the machines being brightly painted, and the walls bear several attractively finished murals depicting ancient and modern craftsmanship.

The company's apprentice training scheme was initiated by Sir Harold West, managing director, in 1942, and in the following year the business training scheme for girls was started. Boys and girls on being accepted for service with the company take a month's pre-entry course designed to bridge the gap between school and industry. For the boy apprentices, in particular, the emphasis during the pre-entry course is on the team spirit. After entering the works in a selected trade, the apprentices return to the training school for one month in every six to continue progressive technical instruction. Those about to enter the Forces are given a "pre-National Service Course," during which they are able to acquire a broad grasp of Service life through talks by Forces specialists, discussions with returned Servicemen, and visits to Service establishments. Apprentices may qualify for release one day a week to attend local technical colleges for National Certificate, Higher National Certificate and City and Guilds courses, individual achievement being encouraged by shop championships and bonus awards for evening school merit. Up to the end of last month, since 1942, nearly 1000 boys had passed through the apprentice training scheme, 175 of them being mining apprentices prior to nationalisation. In the business training centre, since 1943, nearly 400 girls have been trained for office duties. In the ten-year period between 1942 and 1952 Thorncliffe apprentices gained 171 National Certificates.

At the formal opening ceremony, last Friday, of these latest additions to the firm's training and welfare facilities, Sir Samuel Roberts, chairman of the company, presided, and the Minister of Labour spoke of the importance of training in and for industry. The "Thorncliffe experiment," as it has come to be called, was, he said, one in which his Ministry was particularly interested, and was one which was unquestionably proving its value. At the conclusion of the ceremony, the Minister presented awards to several apprentices, including one who has achieved first place in the United Kingdom in the City and Guilds final examination in steelwork fabrication.

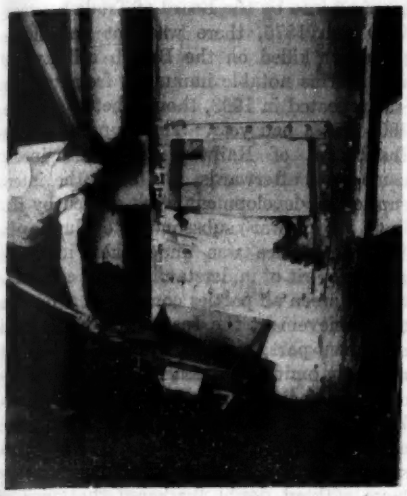


FOUNDRY BATHS BUILDING

APPRENTICE TRAINING SCHOOL

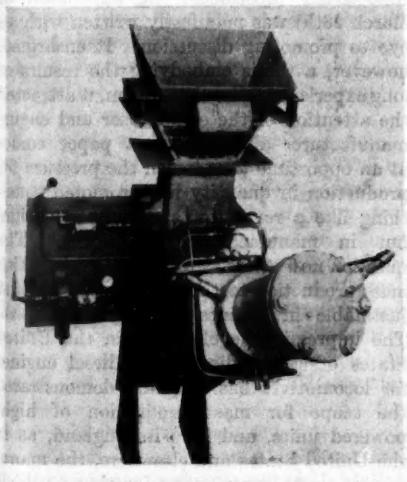
Melting Cast Iron Swarf in Cupolas

A CONSIDERABLE amount of material is lost by industry every year in the shape of swarf machined from iron castings, and a new process, which has been developed by Crofts (Engineers), Ltd., of Thornbury, Bradford, is designed to prevent this waste of metal. This firm was in a large measure prompted to investigate a means of avoiding waste of cast iron swarf to the greatest possible extent as in its machine shops it produces some 40 tons



SWARF FEED HOPPER

of borings and turnings a week. It was decided that if the bulk of this material could be recovered in the cupolas in its own foundries, not only would economy be promoted but a big advantage would be gained in reducing the demands for a material in short supply. As a result of these investigations, the new process was developed and a series of experiments carried out to prove its economic possibilities.



SWARF FEEDING UNIT

Prototype equipment was installed on cupolas in the firm's foundries, and in the course of a recent visit to the Thornbury works we were shown the finalised design in operation on the cupola to be seen in one of the illustrations we reproduce.

In introducing its new process the firm points out that although a percentage of material is recovered in the two commonly used methods of briquetting or canistering cast iron swarf and returning it to cupolas, an appreciable quantity is still lost. This loss in remelting is caused by the bursting of the canisters or the disintegration of the briquettes when they are crushed by the remainder of a cupola charge. When this crushing occurs the upwards blast carries the light particles forming most of the swarf up out of the cupola into the atmosphere.

The new process simply consists of injecting the borings as received from the machine shops straight into the cupola, just above the melting zone. At this point the coke, limestone, solid metal and other materials making up the charge, are packed sufficiently tightly to obstruct and prevent the light particles being picked up by the blast and ejected from the cupola. Because the swarf enters the cupola at this particular level it is rapidly heated to melting point and the period at which oxidation of the material and sulphur absorption takes place is reduced to a minimum. It is claimed that the wastage in the melting process is similar to that incurred in normal cupola melting of pig iron, steel and scrap—about 3 per cent. Experiments carried out by the

SWARF FEEDING UNIT ON CUPOLA

firm in its own cupolas are stated to show a saving of some 33 per cent in the consumption of pig iron, purchased scrap and heavy steel. The apparatus developed for the process can be adjusted to feed swarf to form from 5 to 25 per cent of the metal charged.

The swarf feeding unit can be seen in the photographs we reproduce on this page. It consists essentially of a hopper, which is set at charging platform level. Swarf fed into this hopper gravitates down a chute to a feed chamber at the point where it is required to introduce the material into the cupola. A compressed air operated ram reciprocates a feed bar, which pushes the swarf into the cupola on each forward stroke. At the end of each backwards movement of the bar there is a brief dwell period, during which the swarf in the chute fills all the space in the feed orifice. The frontal area presented by vertical fins on the feed bar is sufficient to force the mass of swarf into the cupola at a predetermined rate. In the event of the swarf being fed too rapidly and packing above the melting zone the resistance it sets up is sufficient to hold the ram back against the working air pressure without danger of damaging the mechanism.

When the ram feed is switched off the bar is automatically retracted to its rearmost position away from the heated zone of the cupola lining. The ram is not cooled as the flow of swarf over the bar provides an effective cooling medium. We are informed that feed bars have been in service for four to six months without signs of excessive distortion or wear occasioned by over heating. When the swarf charging unit is in operation the mass of material in the chute effectively prevents any upward flow of gas to the charging platform. A small vibrator in the chute hopper assists smooth downward flow and prevents bridging of the material. When the level of swarf in the chute drops below a predetermined position the feed apparatus air supply is automatically cut off.

The feed ram has a stroke of about 9in and it can be driven at up to about thirty-two strokes per minute. In a typical application with a feed cycle of fifteen strokes a minute to feed some 15 cwt of swarf per hour into a cupola, the machine requires about 10 cubic feet of free air per minute at 80/90 lb per square inch.

The apparatus is supported on a cupola by large adapter plates at the feed hopper and feed chamber ends. These adapter plates are shaped to standard cupola forms so that the apparatus can be fitted easily to existing installations. The makers state that the feeding unit can be installed ready for operation in as little as twenty-four hours on standing plant.

In addition to the economy promoted by remelting the cast iron swarf the apparatus is also being used at the Croft works to use up the coke fines normally discarded. This broken coke is fed up to 4 per cent by weight with the swarf to give an increased coke/iron ratio where it is particularly desirable.

Inventors and Industry

THE National Research and Development Corporation was established in 1949. Judging by the reports that it has since issued it appears likely to restrict its activities mainly to the handling of inventions partly developed at D.S.I.R. research stations or by other research bodies. For only a very small proportion of the many other inventions that have been submitted to it have been adopted. Indeed, its purpose is only to support inventions likely to prove of "national" importance. We now learn that a firm entitled "Approved Inventions, Ltd." has been set up with independent private capital. Brigadier McNair, who was chief executive engineer of science staff for the Festival of Britain last year, is chief technical officer and a director of the new company. The object of the company will be to act as a clearing house for all ideas, inventions, &c., whether patentable or not, which do not fall within the more constricted ambit of the corporation. For a small fee an inventor will be given advice as to whether his invention seems likely to have a chance of success; and in promising cases the firm will recommend the invention to a firm or organisation that seems able to make use of it or, possibly, set up a separate company to exploit it. It is intended to form a register of new ideas which are considered to be of value and technically sound and to circulate the list periodically to all organisations on the firm's subscription list. In effect the firm will act as an agency to serve industrialists who wish to find inventions that might profitably be exploited and inventors who seek firms which might prove willing to develop their ideas. The address of the new firm is 7, Princes Street, Hanover Square, London, S.W.1. Telephone: Mayfair 3163.

EUROPEAN FOUNDRY MISSION TO U.S.A.—A technical assistance mission, sponsored by the Organisation for European Economic Co-operation, and representing European foundry interests, is to have as its secretary, Mr. John Bolton, technical secretary of the research and development division of the British Steel Founders' Association. During a four weeks' tour of American foundries the mission, which comprises delegations from the principal West European countries, will visit the International Foundry Congress being held at Atlantic City from May 1st to 7th.

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RAILWAY SIGNAL ENGINEERING

AMONG the arts associated with the development of railways there is none more specialised and none based more surely upon the experience of past years than signalling. In the course of a delightful presidential address to the Institution of Railway Signal Engineers, on April 2nd, Mr. T. S. Lascelles, managing director of the W. R. Sykes Interlocking Signal Company, took his audience back some forty-two years to the time when the idea of the Institution was first mooted, and gave a vivid account of the stage to which railway signalling in Great Britain had then developed. The time was then no more than eighty years after the establishment of railways as a reliable means of transport; but while mechanical signalling practice had, in 1910, reached a high degree of completeness and elaboration, there were some who felt the need for closer co-operation between railway engineers and the manufacturers of signal apparatus, and no less between both those parties and the Government inspectorate, then a responsibility of the Board of Trade. Conditions were vastly different from the happy state of collaboration that exists to-day. On that point Mr. Lascelles could speak with outstanding authority, for as his predecessor remarked before conducting him to the chair, he had, during the forty years of its existence, served the Institution in every conceivable capacity: as ordinary member, as member of council, as librarian, as treasurer, as secretary, and now as president.

Mr. Lascelles devoted the major part of his address to the fascinating subject of signalling history, as reflected in the Board of Trade requirements. He told how the growth of traffic on the railways, and the increased speed at which it was conveyed, led to a very large number of fatal accidents over which there was naturally deep public concern. It was not until 1871 that a Board of Trade inquiry into every fatal accident was made compulsory, and the activities of the inspecting officers were, as often as not, looked upon with suspicion by railway officers. Far from receiving any co-operation, they had to face thinly-veiled hostility. In other ways, too, their work was most strenuous. One officer, asked by the Board of Trade to examine a certain length of main line railway 75 miles long, had to cover the entire distance on foot, and in the course of his inspection he found no fewer than 11,200 defective rails! But as the activities of the inspecting officers increased so successive editions of the Board of Trade requirements for new lines included specifications more precisely related to the needs, and to the shortcomings, of railway practice and equipment, though in general the "requirements" set forth could not be made retrospective. With signalling equipment many individual items of apparatus came to be patented, and for such appliances other manufacturers could market competitive articles only by circumventing those patents. Complication in design tended to increase, and Mr. Lascelles told how one of the most famous of inspecting officers of Victorian times, Captain Tyler, read a paper before the Royal Society of Arts, stressing the need for simplicity in design of railway equipment. The standard of education of the men who had to use such apparatus was an important consideration; the illiteracy of signalmen retarded the introduction of railway telegraphs and block working, though, on the other hand, there were eminent men who held other views. Brunel, for example, the famous chief engineer of the Great Western Railway, at one time thought it was decidedly risky to have on the footplate any man who could read!

Gradually the campaign waged to secure greater safety began to have effect. The requirements of 1874 made compulsory the use of the absolute block system on passenger lines and required the interlocking of all points and signals. By that time, too, the signals themselves were required to be designed in such a way that a broken connection would result in the arm taking up the danger indication. This important provision has since been extended to become a major point of principle, not only in the mechanical design of signalling apparatus, but in power signalling circuits, wherein a failure results in a red indication being displayed. Mr. Lascelles brought out an interesting point though not directly connected with signalling, that in later years the number of fatal casualties in accidents was lessened by the carrying of first aid and rescue appliances on trains, and by the encouragement given to railwaymen to learn first aid. The first railway ambulance classes were held at Paddington, G.W.R., in 1879. With the issue of the Board of Trade requirements for 1892 practically all the generally accepted features of pre-power signalling days in Great Britain were incorporated, and against the high record of 1100 fatal accidents inquired into by the Board of Trade between 1860 and 1875, there was not one single passenger killed on the British railways in 1901. This notable immunity from mishap was repeated in 1908, though between them 1906 was a bad year. The founding of the Institution of Railway Signal Engineers came soon afterwards, and after the interruption of development work caused by the first world war subsequent evolution in British practice was undertaken in a far greater spirit of understanding and co-operation between all parties concerned. Towards this achievement the Institution has played no mean part, though the new president modestly omitted to mention anything of his own personal contribution to that success. He is a signal manufacturer, and, in addition, a man of wide interests. His close studies of Continental signalling practice have without doubt furthered the spirit of happy co-operation between the Institution and signal engineers in France, Belgium, the Netherlands, Scandinavia, and elsewhere, many of whom are full members, and have contributed notable papers to its *Proceedings*.

I.C. ENGINES AND THEIR USES

THE paper contributed by Mr. A. K. Bruce on March 20th to the Diesel Engine Users Association (abstracted in our issue of March 28th) was manifestly written with an eye to promoting discussion. It enshrined, however, a thesis embodying the results of long experience. For that reason, it attracted the attention of the engine user and engine manufacturer alike. Such a paper comes at an opportune time, when the pressure for production in quantity has promoted something like a revolution not only in design, but in manufacturing techniques. The question now arises as to the extent to which mass production methods are applicable and justifiable in engines of appreciable size. The impressive development in the United States of standardisation of diesel engines for locomotives has certainly demonstrated the scope for mass production of high-powered units, and here in England, as in the United States and elsewhere, the manufacture of compression-ignition vehicle engines has shown the extent to which the quantity production of such machines can be combined with quality production.

While there can be no doubt that the needs of specific duties call for engines of different categories, it is surely desirable that efforts should be made to reduce the number of existing types. For example, the basic needs of a geared marine engine of small size do not differ widely from the needs of an engine of comparable capacity geared to a waterworks pump

or, indeed, from those of an industrial unit of equivalent power and speed. If the same engine can be successfully employed in a number of services, the manufacturing advantages are obvious, and in these days, when craftsmen are scarce, such standardisation is certainly something to be strongly encouraged. We would urge again, therefore, as others have urged before, that it is in the interest of the oil engine building industry to concentrate on the fewest possible types and the fewest cylinder sizes. This concentration should, of course, be associated with high quality manufacture and the utmost refinement in accessories. But there is another consideration which cannot be lost sight of. It relates to the pressing need to make the most effective use of materials. The effort of designers to reduce the weight per horsepower is continuous and worth while. It must not, however, be carried so far as to involve sacrifice of reliability. The same is true of the urge to attain phenomenally low fuel consumption irrespective of practical requirements, among which reliability stands pre-eminent. In that connection, Mr. Bruce quoted a translation of those memorable words of Sadi-Carnot: "L'économie de combustible n'est qu'une condition que doivent remplir les machines utilisant la chaleur. Dans beaucoup de cas, elle n'est que secondaire. On doit donner souvent la priorité à la sécurité, à la puissance, à l'endurance de la machine." It is certainly true that Carnot's words may be regarded as having "sovereign authority," but just as the effective output per ton of steam engine weight has been increasing since the days of Newcomen, so also has the output of the oil engine, and there can be no finality in progress whether in the direction of greater economy or higher power-to-weight ratio. That there remains a field for the large slow-speed marine engine is certainly true, though we believe that here also engine size and particularly engine weight will, by the adoption of improvements in design and the increased use of materials of greater strength, tend to become less.

No aspects of oil engine performance are more important than those of reliability and maintenance cost. But they are matters which do not lie entirely within the control of the designer and manufacturer, since operation and maintenance are necessarily in the hands of the user. Moreover, a great change has come over manufacturing methods. More and more the skilled fitter is being eliminated in favour of the machine minder and assembling hand. This revolution is having the effect of emptying the reservoir of skilled men and thus intensifying the problem of maintenance. No one can doubt now that the shortage of really skilled erectors, watch-keepers and maintenance men verges on the perilous. Mr. Bruce, dealing with that shortage, remarked that "Engine maintenance is not a science which can be learned by knowing, but an art which can only be learned by doing. . . ." Nothing that can be done by the designer or by instrumentation will take the place of experienced watch-keeping engineers and maintenance men. They are entirely indispensable. The place to produce them—after wise selection—is the factory in which the engines are built, and there is no department of a works which can be more valuable in contributing to long-range reputation than the department which sees to the evolution of skilled erectors and fitters. This was true at the very beginning of the engineering industry when James Watt, greatly worried by the lack of skilled men, kept his star fitter, William Murdock, working day and night. It is very true, and we shall do well to recognise that the evolution of efficient machinery must proceed concurrently with the evolution of men skilled in operating and maintaining it. In conclusion, the attention of designers must certainly be directed more than ever to the need for the utmost accessibility, simplicity and security. By keeping in mind the problems of maintenance they will lessen the hazards inseparable from operation.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

ASSESSMENT OF LOCOMOTIVE PERFORMANCE

SIR,—In reply to Mr. F. L. E. Beedham, who, incidentally, does not say whether or why he expects steam chest pressure on an A.3 at full regulator to be higher or lower than 205 lb per square inch, I have to say that the facts are as stated and that a boiler pressure of 220 lb does not conflict with a steam chest pressure of about 205 lb at normal running speeds.

A pressure drop of this order is what one would expect from an orthodox design of the 'twenties. The characteristic power equation for an A.3 at normal running cut-offs is $P_n = P_c\left(1-\frac{1}{32}\sqrt{n}\right)$ in respect of the outside cylinders and $P_n = P_c\left(1-\frac{1}{39}\sqrt{n}\right)$ in respect of the inside cylinder, where P_n is the mean pressure at n r.p.m., P_c is the calculated basic mean pressure, and n the number of revolutions per minute.

Since Mr. Beedham appears to be interested in the phenomenon of pressure drop between boiler and steam chest, I subjoin details of investigations on two other well-known designs of the 'twenties.

Example 1.—*G.W.R.* 7 *P.* "*Caldicot Castle*" (*Designed* 1923)

225 lb boiler pressure. Full regulator.

Average steam chest pressure (inside) 208 lb per sq in
Average steam chest pressure (outside) 211 lb per sq in

Example 2.—*L.N.E.R. B.*17, 2861 (*Designed* 1928)

200 lb boiler pressure. Full regulator

Cut-off, per cent	Range of speed, m.p.h.	Range of steam chest pressure, lb per sq in
15	40–70	190–190
25	40–70	186–186
35	30–52	185–182
45	30–45	183–178

JOHN D. MUNNION

Chelmsford, April 4th.

THE "BRITANNIA" LOCOMOTIVES

SIR,—Your interesting leading article on these machines states that slipping at high speed is accepted as the probable cause of the movement of the wheels on their axles and also that similar slipping has been experienced with large overseas engines having roller bearings to their coupled axles.

I would suggest that the roller bearings themselves may not be the culprits, but rather the method of mounting. The cannon box assembly, together with hard metal contact surfaces in horns machined to a very small clearance, give an arrangement that could not be expected to work freely in anything but a perfectly rigid frame; the least distortion of the latter would cause binding, and no locomotive frame can be made quite rigid.

Axleboxes with minimum play in the horns are, of course, desirable, but one wonders if it is not being carried a bit too far with these modern unwearable surfaces that cannot adjust themselves like the old white metal. After all, we have had a quite serious derailment recently, due to the sticking of a bogie axlebox in its horns.

C. M. KEILLER,

Bexhill-on-Sea, April 5th.

[We leave others to comment on this letter. But in fairness to roller bearing manufacturers we feel we should point out that our article also referred to slipping by "Pacific" locomotives with plain bearings. Our suggestion, in fact, was that the "Pacific" as a type is prone to slipping.—ED. THE E.]

Literature

Punched Cards: Their Application to Science and Industry. Edited by ROBERT S. CASEY and JAMES W. PARRY. Reinhold Publishing Corporation, U.S.A. London: Chapman and Hall Ltd., 37, Essex Street, W.C.2. Price 80s.

THIS book is less comprehensive than the title might indicate. No accounting applications are described and most of the book is devoted to coding and to the related problems of indexing and the selection of information, the increasing magnitude of which is emphasised. Its main appeal will be to the chemist and to the librarian. Consideration is largely, but not wholly, restricted to manually sorted cards as distinct from machine-operated systems. In fact, the preface states that one object has been to make the book serve as an operating instruction manual for the edge-punched cards.

Part I gives a review of fundamentals and covers in considerable detail the operation of these manually operated systems. The machines used in the machine-operated systems are described, but in considerably less detail. In this respect it might be pertinent to quote again from the preface, which states that "The full possibilities of their applications are so vast that it is not possible to set down in one place all operating instructions." They advise that "detailed directions for each application must be obtained through consultation with technicians from the manufacturers." The value of punched cards in library operations and in abstracting and information services, already introduced to European readers in an O.E.E.C. report, is fully described in Part II. Interest in the Batten system of patent searching will not be limited to those engaged on patent work, and all library executives will find these chapters relevant, and controversy on the merits of the U.D.C. system will be revived by this book. Some chapters of Part III on general and fundamental considerations, also cover this ground. The four brief chapters in Part II dealing with the use of punched cards in industry are clear and simple to understand and follow the orthodox pattern for applications of this nature.

Two chapters of Part III are devoted to scientific calculations. One gives an elementary and superficial discourse on correlation, but hardly mentions how machines may perform the actual calculations. The other, on scientific computation, contains an interesting section on symbolic logic and indicates how electrically sensed machines are used in research establishments. Skilled com-

puters may not share the author's misgivings about the value of tables now being produced on a large scale, and his preference for tables at small intervals of the argument in which interpolation is unnecessary is in general unjustified. The choice of programming example is unfortunate as the evaluation of $aT+bT^2$ only requires two and not three runs through most multiplying punches. A strange footnote on page 414 states that there are $10^7\pi$ seconds in a year. Surprisingly the book makes little mention of the production of frequency tables, which is probably the main application of machine-operated punched cards in industry and science outside pure accounting.

The chapters devoted to coding are in the nature of a mixed bag and are confined to the highly specialised field of chemistry. The art of coding lies in the allocation to physical items (or nominal ideas) of symbols (or patterns of symbols), which will serve as shorthand expressions. The first requisite of such symbols is that they shall identify uniquely each item so that no two symbols denote the same item and, what is equally relevant, no one symbol shall denote two different items. The ability of Carl S. Wise's Word Coding (Chapter 6) to achieve these ends in any but the very narrowest field is in the reviewer's opinion open to question. Further, the maintenance of indexes to ensure uniqueness of coding will vitiate the usefulness of the system, which will thus be no more efficient than a serial numerical system, without its simplicity.

In an entirely different class is Chapter 26, by Norman T. Ball, on classificatory coding, which though of necessity treating the subject somewhat briefly, does, in the main, display a sound approach to a complicated problem. The broad treatment employed by this author contrasts very favourably with the much narrower outlook of others in the book. The problem of the assimilation and ready extraction of a large amount of published information, especially in chemistry, and the future possibilities of applying mechanical methods are discussed in some detail by Dr. E. H. Eric Pietsch. The book concludes with a biography covering most of the published information on uses in the scientific as distinct from the commercial and industrial spheres.

A book of this nature containing contributions by various authors inevitably reveals repetition and overlapping, some of which could have been avoided by careful editing, but the editors state that such overlapping is not wholly undesirable." Gobbledeydook " is largely absent, but an English reader may well shrink when he sees " Activating Unwieldy Files " as a chapter heading.

Mechanics Applied to Vibrations and Balancing. Second edition. D. LAUGHARNE THORNTON. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 50s. WHEN Mr. Thornton's book first appeared in 1939, it was generally predicted that it would be ranked as one of the authoritative textbooks on the subject of vibrations. The passage of time has fully justified that prediction and the publication of a second edition occasions no surprise. It is, indeed, almost superfluous for the present reviewer to add his commendations to those accorded it in its first edition, particularly as the greater part of the earlier edition appears unchanged in the present volume. The author has restricted his revision to the final chapter which contains a general review of the subject; this has been almost completely rewritten. One entirely new chapter—on dynamic loading of structures—has been added.

The book commences with a treatment of the theory of the balancing of engines, in the first place by the simple principles of mechanics, followed by a statement of Lagrange's equation, which is then applied to particular cases of balancing, and also to the stability of governors. The next chapter is devoted to the problem of the balancing of locomotives, Lagrange's method being applied both to the main motion and cranks and to the valve gear. The theory of vibrations is outlined in the next chapter and illustrated by a number of excellent problems. The problems are, in fact, a feature of the book, being both illustrative of the fundamentals and, at the same time, of practical value. The vibration of systems with several degrees of freedom are dealt with generally and also the vibration of structures, of engine-driven alternators, and of nose-suspended traction motors.

Chapter IV contains a remarkably good treatment of the propagation of stress in elastic materials, the associated problems covering a great range of experience, from fuel injection systems to earthquakes, and water hammer to reinforced concrete. The following two chapters deal with beams and plates and with rotating discs and shafts, including the theory of whirling.

The chapter on dynamic loading of structures, being new and introduced to this edition, calls for more detailed comment. Longitudinal, flexural and torsional vibrations are reviewed, followed by a section on damping and plasticity. In this regard, no reference is made to the methods of determining the damping capacity of metallic materials developed in recent years. In the discussion of plasticity, the author refers only to the work of early writers on this rapidly developing subject, the greatest developments in which have occurred in the last twenty years. This section and the succeeding sections dealing with plastic strain waves is disappointing, and hardly up to the high standard of the rest of the book.

The final chapter, which is a general survey of both the contents of the book and the whole field of vibration mechanics, has been largely rewritten, as a glance at the first edition will show. In the discussion of the physiological effects of vibration it does not appear that the author is aware of the experimental fact that it is the rate of change of acceleration which determines whether an unpleasant sensation is felt, not the rate of acceleration itself. A brief reference is made in this chapter to vibration absorbers, particularly those devices for absorbing torsional vibration in crankshafts followed by an interesting examination of the vibration of a helical spring in which the diameter of the coils varies regularly from one end to the other of the coil.

The problem of predicting the vibration of ships, particularly those with diesel engines, is becoming increasingly important. The existing experimental results of the observed frequencies of vibration in ships are compared with the values calculated by various authors. The agreement is very good for the two-node mode, but no information is given as to how allowance has been made for shear and for the virtual mass of the ship. Recent experiments and calculations do not show such close agreement, particularly for the three and four-node modes, despite the thoroughness of the experimental technique and the complexity of the calculation. The positions of the nodes are not very exactly predicted and it would seem that this is an important field for further investigation.

This is indeed a formidable textbook and one which will repay careful and frequent study. Both the author and the publishers are to be congratulated on the excellent appearance of the book; the layout is attractive and the print and figures are clear.

SHORT NOTICES

A Guide to the Principal Safety Requirements of the Factories Acts, 1937 and 1948. London: The Royal Society for the Prevention of Accidents, 52, Grosvenor Gardens, S.W.1. Price 15s.—The information given in this guide is particularly intended for the use of factory managers, engineers, factory management staff, supervisory grades, labour departments, legal departments and others concerned with management, safety and welfare of workers to enable them to check their responsibilities under the Factories Acts and the Regulations made under them.

The guide has been classified under fifteen sections and all items in these sections have been indexed and cross indexed to provide a comprehensive reference to some of the complexities of the Factories Acts and the many Statutory Instruments which are legal requirements under these acts.

The book is not in any way intended to be a legal guide and in it no attempt is made to interpret the requirements or to give advice on fulfilling them. It presents clearly and concisely the definitions, direct requirements, exceptions and exemptions under the acts, and lists under each section the full title and number of the Statutory Instruments concerned. Each page has marginal reference to the sections and sub-sections of the Acts involved, the numbers of the legal forms to be used and the Statutory Instrument related to the context of the paragraph.

The Great Western Railway : An Appreciation. By O. S. Nock. Cambridge: W. Heffer and Sons, Ltd. Price 18s.—In the Preface to this volume the author says: " My aim has been to present a picture of the line as a well-knit going concern as it grew and as it served successive generations." In this aim he succeeds admirably. Mr. Nock is familiar with all the British railways, but with none so much as with the Great Western, which he has known and loved since his boyhood. Here he traces the history of the most famous railway in the world from its inception as the " London and Bristol," and the appointment of young Isambard Brunel as its engineer, through its career as broad gauge, up to the present, when its individuality has been threatened by nationalisation and standardisation. It is unnecessary to say that Mr. Nock tells his story excellently. Readers of THE ENGINEER are too familiar with his pen to expect anything less. His narrative is helped by a number of good maps and by many photographs, and if he does lean—as he himself admits—just a little to the technical side, readers will find plenty to interest them in the account of runs made with famous trains and in his talks about train control, signalling, auto-trains, docks, and so on.

Compressed Air in Mining and Industry. Edited by S. H. North. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 18s.—This book is intended to guide prospective users in the selection of compressed air plant and equipment for carrying out any particular work in mining, quarrying or industry. The various sorts of compressors and pneumatic tools are described, with notes on the care of the tools. There are chapters on compressed air in mines and quarries, industry and constructional and public works. Pneumatic appliances generally form the subject of one chapter, and there are notes on the pneumatic conveying of materials.

Tabulating Machine Factory

To meet the greatly increased demand for its equipment, the British Tabulating Machine Company, Ltd., has laid down a large new factory at Castlereagh, near Belfast, in Northern Ireland. This factory, which was officially opened on Wednesday last, April 9th, is equipped to manufacture various kinds of ancillary equipment such as Reproducers, Interpreters, Collators, Multipliers, &c., as well as Tabulators.

SOME forty-five years ago the British Tabulating Machine Company, Ltd., was formed to acquire from the International Business Machines Corporation of America the manufacturing rights of Hollerith machines in the British Empire, and in 1920 the British company set up a factory at Letchworth for making machines which had, up till then, been imported from the United States. Prior to 1949, when the agreement between the two companies was terminated by mutual consent, the policy of the British firm had been to manufacture at Letchworth basic machines, i.e., punches, sorters and tabulators and to import other ancillary equipment from America. When, however, the demand for this other ancillary equipment reached sufficient volume to justify the capital expenditure the necessary tooling up was undertaken. For this reason, by the time importing of machines from America ceased, the company was virtually in a position to rely on its own resources for complete ranges of punched card machinery for the satisfaction of immediate needs.

During the war years, the demand for the machines increased to such an extent that the productive capacity at Letchworth fell far short of requirements, and as in the next few years the demand showed no sign of abating it was decided to build a new works. Once this decision had been made, possible sites in many parts of the country were inspected and it was finally decided to establish the factory at Castlereagh, near Belfast, in Northern Ireland.

This new factory has now been officially opened, and it is laid out for the manufacture of what might be termed standard ancillary equipment and certain new types of machines, whilst the capacity at Letchworth is mostly devoted to the construction of tabulators. In planning the new works, provision has been made for future reorganisation and expansion and the quick and smooth change-over from one production programme to another. The works have been organised and put into production by a small nucleus staff from Letchworth, and this group has been responsible for training the large number of hands recruited from local sources.

The factory at Castlereagh, as can be seen from the photographs we reproduce, comprises two main buildings, the larger of which is primarily concerned with component manufacture, and the smaller with the assembly and testing of machines.

The factory has a planned production area of 177,000 square feet, with a stores area of 21,000 square feet, and an office area of 36,000 square feet; the ancillary departments and buildings cover a further 18,000 square feet. The two main production buildings are single-storey structures, fronted by two-storey office blocks. In the larger building advantage is taken of the large amount of office space available to use the lower floor of the office block to provide accommodation for stores, inspection and production control departments, a tea centre, &c. There are no obstructions on the shop floors other than the minimum of roof supports. The office walls are of hollow bricks or movable steel partitions, and the stores, inspection departments, control offices, &c., are all enclosed by steel partitioning. All the walls can be removed and re-built without need for major structural alterations, and the partitioning taken down and re-erected if future circumstances necessitate changes in the factory layout.

The smaller of the two buildings, which is one of the standard factories being erected by the Government of Northern Ireland, was completed first, and it was equipped and used as a pilot unit whilst the main building was being constructed. The completion of the smaller building at an early stage in the programme, provided the nucleus staff from Letchworth with ample space and opportunity to prepare the new equipment for the main works and train a fair percentage of new hands for the class of precision work they would be required to do when full production began. When the main building was completed it was set into operation department by department with the machines tooled up and the hands trained in the first factory. All this staff training and equipping of the production lines was carried out to a carefully arranged plan and the production thus started at an early stage progressed steadily as the machine and assembly lines were laid down and extended.

The Main Factory

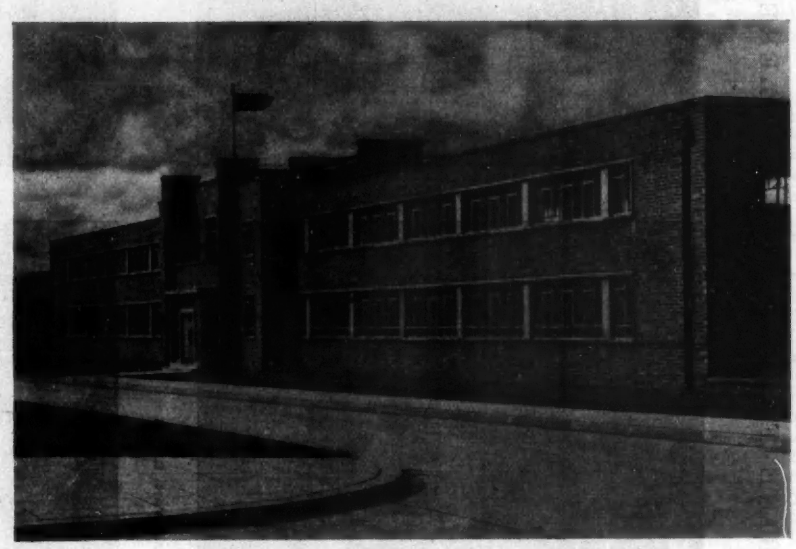
The production flow in the factory is from west to east with the goods inwards section at the west end of the main building and the despatch department at the east end of the assembly shops. All raw materials and purchased components are delivered to the factory by road vehicles, which are unloaded at a dock in one corner of the main building. This dock is served by a 3-ton overhead hoist, and from it goods are passed straight in to a quarantine and inspection stores, where they are checked before being released to the main stores. Raw materials are retained in stock for issue to the adjoining production lines, whilst component units and materials not for processing are sent straight through the works to the finished part stores on the main assembly shop.

The machine lines are laid down across the width of the main shop in manufacturing sequence, and an impression of the layout can be obtained from some of the photographs we reproduce. The press lines at the easternmost end of the shop are followed by groups of automatics, capstans, grinders and millers, preceding a group of miscellaneous machines—including gear-cutting machines, rack cutting machines, a broaching machine, &c.—then come the lines of drills and a dressing section for machined parts. At the end of these main machine lines is a large toolroom, partitioned off from the remainder of the shop, and a special order department. In this special order section are made parts which, by reason of their small number or intricate nature, are not suitable for manufacture by quantity production methods on the main lines. At the western end of the shop is an apprentice training section, a factory maintenance department and the sheet metal working section.

As can be seen from the illustrations, a particularly noticeable feature of the works is the wide spacing of the machine tools and the free access given to all parts by wide gangways both between the machine lines and running down the full length of the shop in the centre and each side. This ample spacing not only gives freedom of movement to the operators, but also full and free access for the stillages, trucks, &c., delivering and removing work. Although it is planned to increase the number of machines at present installed by about a third at some future date, there will still remain plenty of room for good spacing without congestion in any section.

In anticipation of new plant and to provide for the possibility of plant re-arrangement to suit new needs of production, an unusual, though effective means, has been adopted for bedding the lighter machines not subject to vibration. Such machines are set in position with a sheet of builders' paper between their bases and the floor, and a shallow ledge of concrete is then set round the base. When it is required to alter the position of a machine, the ledge of concrete is quickly and easily chipped away, and the machine is free to be moved, leaving no bolts or holes in the floor to cause obstruction.

All the machines installed are motorised, and a practice which has been adopted for coupling them to the power supply is designed to facilitate and speed their re-positioning when the occasion demands. An overhead power supply trunk runs the full length of one side of the building, and from this trunk are fed sets of busbars arranged at intervals across the width of the shop over the machine lines. Tapping points are set at 2ft intervals along the busbars, and when a machine has to be moved, its feed cables can be disconnected and re-coupled to the power line at the new station in a matter of minutes. With the exception of the automatics, most of the machines are engaged on relatively short-run batch working and, to maintain a smooth production flow with a minimum of delay between operations, three production control sub-offices are spaced along the main gangway through the machine lines. As each batch of components is completed, its work card is handed in to the clerk at the appropriate sub-office. This card is then stamped by the clerk and sent via a pneumatic tube straight to the work controller in the main production control office. The controller returns to the sub-office the work card for the next operation or movement of the batch which is then, without delay, sent to its next destination. With this system and the speedy interchange of cards made possible



CASTLEREAGH WORKS ASSEMBLY FACTORY

TABULATING MACHINE FACTORY AT CASTLEREAGH, NORTHERN IRELAND

MACHINE SHOP FROM THE CAPSTAN LINES

GRINDING SECTION OF THE MACHINE SHOP

TOOL ROOM

SORTER ASSEMBLY SECTION

by the use of pneumatic tubes, a controlled movement of work is maintained, whilst delays between operations and chance of loss of cards are minimised.

The degree of accuracy called for in the manufacture of components for tabulating machines necessitates a considerable quantity of high-quality tooling and gauging equipment, and at the Castlereagh works this is supplied by a large toolroom partitioned off from the main production floor. This toolroom is well-equipped with a wide selection of modern precision machines, including two jig borers housed in a temperature-controlled room. In addition to making a large number of press tools, jigs, fixtures, gauges, &c., this shop is responsible for a larger amount of maintenance and repair work than is generally encountered in factory toolrooms. This high loading with tool maintenance work can well be appreciated when the degree of accuracy necessary on the production lines is considered, and there is taken into account the frequency with which such precision tooling on the machines is set up and taken down on short run work. A special section of the inspection department is solely concerned with the checking of all tools, jigs, fixtures, gauges, &c., as they are finished with on the production lines. At the end of a run, the tools and gauges used are sent directly to this section, where they are checked against master equipment for accuracy and efficiency, and inspected for any damage or missing parts. Tools in any way defective are removed to a bond store, from which they can only be taken for repair or re-conditioning by the toolroom. Until such tools are returned as correct by the toolroom and have been passed by the inspectors, they cannot, under any circumstances, be used in production lines. In the inspector's office a history sheet of every tool in the works is kept. The information given on these sheets provides a valuable guide to the efficiency of a tool, and shows any weak points in design which can be taken into account when designing new equipment. When a tool has been repaired or re-conditioned, a note is sent to the patrol inspector on the line concerned when it is re-issued, and the first components produced with it are sent into the main tool inspection section for special checking.

In addition to a central inspection department through which all manufactured components have to pass, patrol inspectors are continually moving about in production lines, checking work in progress. The first-off parts in all runs have to be checked and passed at inspection stations on the machine lines before the run is put under way.

A group of ancillary process shops, situated at the outgoing end of the main production floor, accommodates the heat-treatment, plating, de-scaling, shot blast, enamelling and other finishing departments.

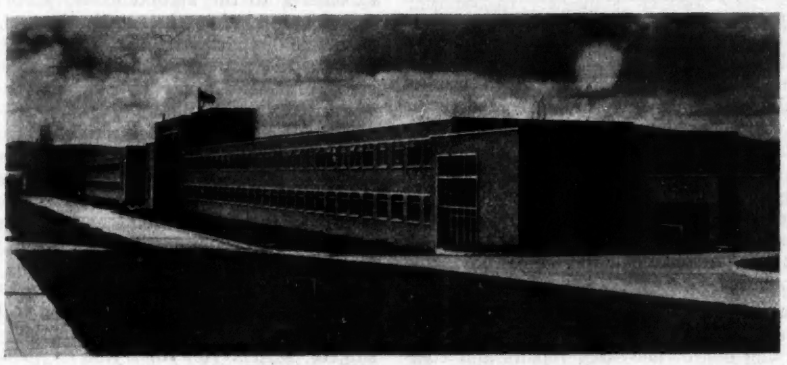
The Assembly Shops

Components from the production shops are transported by electric trucks to the finished parts stores on one side of the assembly shops in the second factory. In these stores, the complete sets of components required for each machine are batched for issue to the assemblers.

The main floor of the shop is divided into sections by wide gangways, and in each section a particular kind of machine is assembled by teams of specially-trained personnel. At present, the seven main sections of the shop are concerned with the assembly of interpreters, multipliers, "Keystor" automatic punches and programme board verifiers, sorters, collators, reproducers and gang punches, and special machine assembly. Another section is engaged in sub-assembly work for the main sections, the making of wiring harnesses, &c. One of the photographs we reproduce shows the sorter assembly section, and is typical of the conditions under which work is carried out in other sections.

At the completion of its assembly, each machine undergoes a test running period, and to provide power for the various motor drives, a special transformer plant has been installed in the shop. In this plant three mercury-arc rectifiers and two motor generators provide d.c. current in ranges of 90V to 150V, and 190V to 250V, to a bank of selector switches. Numbered pendants at various points of the assembly floor can be coupled to appropriate selector switches on the main power supply switchboard, and through them, current at the required voltage can be supplied for running any particular machine in any part of the shop.

Good natural lighting is provided throughout the factory by extensive roof glazing, and artificial lighting is provided by fluorescent tubes arranged to give a general illumination of 15 to 20 foot-candles in the offices and assembly sections, and 12 to 15 foot-candles in the machine lines. Working conditions are made as attractive as possible by the use of a good general colour scheme in green and light stone, with the machines painted a lighter shade of green. Steam for heating the factory is supplied by four hopper-fired boilers in a boiler-house adjoining the main buildings. These boilers are each capable of supplying 5000 lb of steam per hour for the unit heaters in the workshops, and the radiators in the offices of the factory.



CASTLEREAGH WORKS MAIN FACTORY

Training of Employees

In putting this factory into production, the skilled staff from Letchworth has been responsible for a considerable amount of intensive training, as most of the local labour available was not accustomed to the particular class of precision work required. In order to provide a supply of skilled personnel in the future, the long-established practice of the parent works was adopted at an early stage of the new factory's programme, by introducing an apprenticeship scheme. Under this scheme, twelve boys are taken on each year for a course lasting five years. For the first eighteen months these boys serve under the direct instruction of an apprentice supervisor in a special section of the work shops. During the basic training, the practical work of the lads is supplemented by theoretical instruction, which is given in a well-appointed lecture room in the main office block.

When the apprentices have completed this basic training, they are sent out to work in the various factory departments for a further eighteen months. During this period, each lad works in the production and assembly shops, as well as in other sections, such as the toolroom, stores, progress and design departments. By the end of this period, a fairly comprehensive knowledge of all the main aspects of the firm's works organisation has been given, and with this background, each lad is encouraged to specialise in some aspect of Hollerith production during his last two years.

As the firm's plans mature, and its production lines increase, it is expected that this apprenticeship scheme, combined with the general training of staff on the shop floors, will do much to provide the skilled workers it requires,

A Training Centre for Boys

Practical work in engineering and blacksmith's shops, and on a model rubber plant, is now being done one day a week by all boys reaching the age of sixteen at the general rubber goods factory of the Dunlop Rubber Company, Ltd., in Cambridge Street, Manchester. The aim of the training centre is to give the boys an insight into departments other than their own, so that they may appreciate how their jobs fit into the industry as a whole.

In a workshop well equipped with machine tools the boys make the dies and moulds used in the rubber workshop. This helps to impress upon the boys the skill and the time needed to make equipment for the rubber industry by handling such different materials as brass, aluminium, iron and steel.

Any errors at the initial stage of the training are rectified and instruction in the principles of engineering drawing is given. During lectures on the growing of cotton, so important in the rubber industry, the boys are shown samples of the raw cottons which are "pulled down," to demonstrate the qualities and length of staple of each.

The model rubber plant used in the training is identical to that in the main factory. Training on the subject of rubber includes lectures on its history; the early days of plantation development and where it is produced. The part the ingredients play in making up the final compound is explained and the boys mix samples on the model plant in the rubber workshop.

The course includes a section on "accountancy," where a boy is enabled to appreciate the principles underlying the financial side of running a department. Time and motion study, safety and factory welfare and hygiene are also dealt with in a similar practical manner.

Trainees returning from service in the Armed Forces are given a six months' refresher course (again for one day a week) and recently a supervisory course has been started at the centre for men between twenty-two and twenty-four. The firm estimates that of the boys taking the initial course between 10 and 15 per cent will eventually be suitable for charge-hands or foremen, and 20 to 30 per cent will become capable shop operatives in the works.

Books of Reference

Fire Protection and Accident Prevention Year Book, 1952. Compiled by Geoffrey F. D. Pratt. London: Benn Brothers, Ltd., Bouverie House, Fleet Street, E.C.4. Price 10s. 6d.—This is the twelfth annual edition of a book which presents a great deal of technical, statistical and general information about fire fighting and fire fighting equipment. Particulars of the public fire services of the United Kingdom are given, and there is a special section devoted to salvage corps and industrial and private fire brigades, together with details of appropriate associations and other organisations concerned with fire protection. The chapters dealing with the legal aspects of fire protection, and with industrial accident prevention and civil defence will undoubtedly prove helpful to all in industry whose particular responsibility includes the safety of life and property.

The Institution of Mechanical Engineers

FACTORY MAINTENANCE

A GENERAL meeting of the Institution of Mechanical Engineers, arranged in conjunction with its Industrial Administration and Production Engineering Group, was held in London last Friday, April 4th.

The following paper was presented :—

SOME CONSIDERATIONS REGARDING A FACTORY MAINTENANCE ENGINEERING DEPARTMENT

By MAX BENTHAM, M.Sc., A.M.I.Mech.E.*

In this paper, the author attempts to focus attention on the necessity of a suitable organisation of the maintenance services in factories, whatever their size. His object is to promote discussion and not to put forward an ideal scheme for all plants, which would be quite impossible.

A general survey is made of preventative maintenance measures and breakdown conditions to be met by the department. Consideration is given to the administrative personnel and organisation of work, with reference to the location of the maintenance plant in relation to the factory production machinery, and also to the layout and equipment required for the maintenance department. The author discusses the need of adequate stores for spare parts and consumable goods and, where necessary, well laid-out outside storage areas with good access roads. Suggested ways of controlling workers' time, and hence the cost, are outlined, although it is fully realised that the extent of detail, for proper administration of costs, varies widely with differing products and size of factory. References are made to organisation for a group of small factories, and also a system of emergency posts in large factories.

Attention is finally directed to the existence of undesirable conditions sometimes encountered in maintenance departments.

DISCUSSION

Dr. D. F. Galloway remarked that if one considered the subject matter of the paper and considered the exhortations which were made daily and almost hourly to produce armaments more quickly and exports more cheaply, it was indeed refreshing to be able to think that in the paper there was explained a technique of production, namely, planned maintenance, which would enable things to be done more quickly without its being necessary to call upon the worker to work harder and without its being necessary to reduce profits. Proposals and counter-proposals were made regarding labour and profits when all the while, without making any demands on either side, greater speed and cheaper products which would capture foreign markets could be obtained by applying improved techniques—and the technique with which the paper dealt was one that had been very largely neglected. In the course of his work during the last five or ten years, he had had occasion to go into hundreds of factories throughout the British Isles and make observations on production techniques, and he could say without any hesitation that there were very few factories in which the same attention had been paid to the economy of maintenance as had been paid to the economy of ordinary production. The managements of these factories had judged their success or failure by the yardsticks of speed and economy of production, and they had not paid anything like the same attention or used the same standards in measuring the efficiency of their maintenance departments. He thought there was far too much of a resigned acceptance of the idea that preventive maintenance was part of the burden of overheads and that it was a virtually irreducible part. This experience had been backed up last year when he had made a two months' tour in the U.S.A. observing developments in production techniques. It had so happened that at that time there had been a good deal of emphasis placed on preventive maintenance schemes in the U.S.A., and he thought it might be interesting to the meeting to recall a few examples of reported gains of a considerable magnitude in factories in the U.S.A. In the Cadillac works they had put in a preventive maintenance scheme in which they had started by putting two-thirds of their maintenance personnel on preventive maintenance and leaving one-third of them to deal with breakdowns. In one year they had succeeded in reducing the total staff to one-half of what it had previously been and had reduced maintenance costs by the tremendous percentage of 80 per cent in a five-year period. In another shop where there was a good deal of press work, the cost of maintenance of presses arising from failures had been reduced by preventive maintenance, as opposed to simply repairing breakdowns, by 40 per cent, and after the scheme had been in operation for some time they had managed to reduce the emergency repairs from twenty per week to three per week in a large press shop. To mention a particular point which was of significance to-day when machine tools were on very long delivery, one of the results that had been attained in the Douglas works was that, as a result of preventive maintenance, quite apart from other gains, they had increased the efficient life of their machine tools from values of 5 per cent up to 100 per cent on some of the mass-producing automatics.

In the paper, it was stated : " The essential feature of preventative maintenance is the carrying out of necessary repairs and component replacements at some pre-arranged time when the loss of production from the unit will be a minimum." Although that was an essential feature, he felt that an equally important item was the systematic inspection of plant. A study that had once been made of breakdowns had shown that 80 per cent of the calls for maintenance had arisen originally because someone had not been there to turn a screw with a screwdriver, or to tighten a nut with a spanner, or to squirt some oil into a bearing. It had indeed been proved in many factories that a good deal of the expenditure on maintenance and repair could be avoided by having people there at the right time. In one works in the U.S.A. there was a patrol system in which people patrolled the works and did what was necessary with a screwdriver, a spanner and an oil can. It was possible to assess the effectiveness and the value of such a patrol system by noting what were the maintenance costs for the sections patrolled by each patrolman. This system had been proved economically to produce very satisfactory results.

At the end of the section of the paper entitled " Investigation of Requirements " there was the statement, " Medium and small firms cannot always justify the expense of a separate maintenance works and qualified staff." While that was true up to a point, he thought it should be borne in mind that it would pay them to have the system—in other words, the paper work and the control—to which the author so rightly drew attention at the end of the paper. That system should be instituted in any case, so that, if it was necessary to put the work out, the factory management would know what it was all about. It would be wrong to conclude that the small firm must keep to the old-fashioned system. He knew of an instance in which a firm had not been able to have overall coverage within its own works by having a maintenance department, but merely by having an assistant spend half his time running a card system on the maintenance programme it had been able to cut the overall cost by 25 per cent.

The last point of detail to which he wished to refer was the paper work. He thought it was the paper work of these maintenance systems which often frightened executives. The fact must be faced that it was not the engineer, but often the higher executives, who had to be persuaded in this matter before a proper maintenance system could be installed. Therefore it was essential that meticulous care should be paid to the efficiency of the paper work. In this matter there were really two problems, to the second of which the author, quite naturally, had not referred. They had not only to determine the best techniques and the best kind of organisation for preventive maintenance, but they had also to undertake an educational job. They had to educate executives to the acceptance of preventive maintenance and the realisation of its economic importance, and they had to educate the key workers to enter into the spirit of it and apply the techniques that were necessary.

The Production Engineering Research Association was making a contribution to that end. During that week and the whole of next week the Association were exploring aspects of this sort of maintenance in respect of tools and equipment, and they were giving instructional courses to about 600 foremen from various parts of the country. In two months' time they intended to have a conference for executives on the same subject, with a view to trying to treat the other end of the problem.

Colonel H. Randal Steward said that the work of the maintenance engineer had received quite unusual attention this week, since, in addition to the author's paper, many present would have read the most excellent leading article in last Friday's issue of THE ENGINEER,† which expounded, with that felicity of expression which they had learned to expect in those columns, the vital importance of this unsung branch of the engineering profession. It had been well said that an elaborate system of emergency repair, though essential to deal with unavoidable breakdown of machinery or plant, was not of itself a sign of good maintenance, but rather the lack of it. THE ENGINEER referred particularly to three mishaps which had occurred in recent months—the first concerning a railway derailment, the second the collapse of a passenger bridge at a railway station, and the third the failure of an electric winder. In the words of the article, to none of those occurrences could the word " accident " be applied when defined as " that which is present by chance." Except only when caused by " acts of God," such mishaps as those could be avoided by the exercise of vigilance—in other words, by proper inspection and maintenance. He recommended all those who carried on their shoulders the responsibility for the inspection and maintenance of plant and machinery and thereby—let them make no mistake about it—the safety and maybe the lives of men, but who possibly were not getting the support

* Consulting Mechanical and Civil Engineer, Manchester.

† March 28th issue.

and consideration which those responsibilities warranted, to bring the article in THE ENGINEER to the attention of those who sat in authority over them.

The author focused attention on the necessity for a proper organisation of maintenance services in a large factory or other undertaking, and there was no doubt that this was most essential. In spite of all the popular gibes at unnecessary paper work, no efficient organisation could operate without it, and the larger the organisation the more essential it became, if adequate control was to be maintained. The mere fact that the maintenance department was, of necessity, a spending department made it all the more necessary to maintain rigid control over the efficient employment of labour and materials.

The organisation and the paper work, however, must be tailor-made to suit each individual place. It was, as the author remarked, impossible to put forward an ideal scheme for all plants. The detailed records and costings of relatively minor repair or maintenance jobs could only be justified when there was a specific reason for them, i.e., if the cost was recoverable and must be individually invoiced. In general, what was essential was to know the overall cost per annum for a particular grade of machines or section of a plant, which could then be related to corresponding figures of production costs. At the same time, cumulative monthly figures must be available to the chief engineer for control purposes. Where a major overhaul or reconstruction was concerned, amounting to something over £1000, say, a detailed analysis on the lines of the author's suggestions, could be fully justified and the information thereby recorded was valuable for many purposes, particularly for estimating on similar work in the future.

The author referred very briefly to the sometimes highly controversial point as to whether an article made in the maintenance engineering shop was in fact cheaper than the same article purchased from outside, but he thought there was a clear answer to this, again depending on the conditions and circumstances of the undertaking in question. In the first place, the maintenance engineering department was a form of insurance, and for any insurance some premium must be paid. In his opinion, it was beyond argument that an efficient maintenance staff must be permanently employed. Then they not only had an interest in the firm, but they understood the conditions of working, they were familiar with the peculiar idiosyncracies of each machine, and they knew the individual shop managers or foremen concerned. The one essential requirement of the department, however, was that it should be able to deal promptly and effectively with any breakdown in the plant, to do which the necessary men and materials must be instantly available. This inevitably meant, of course, that slack periods for the maintenance staff would occur, but he could not agree with the author's suggestion that the load could be smoothed out by cutting down the peaks and filling in the valleys. This just would not do. A peak was a peak and must be accepted and dealt with, and not spread over. Breakdowns must be cleared in the quickest possible time if far greater loss was not to be sustained in other directions. This was where the "new work" came in—the provision, through the operations of the drawing-office, workshops and constructional staff, of capital equipment within the capacity of the department's own facilities—in his own case, such things as small wall cranes, lift cars, machinery enclosures, miscellaneous light steel structures, pipe work and duct work in the cold stores, and innumerable other items in constant demand. New work could be pushed forward or slacked off according to the labour available; normal inspection and maintenance was a constant regular load; repairs and breakdowns were always urgent and must always be dealt with at once—or even yesterday!

One of the most difficult problems was the question of pay, particularly where the maintenance staff were working with production departments on piecework or receiving some form of incentive or output bonus. They were perfectly well aware that it was only through their constant care and attention that these men could gain the production bonuses which brought their pay packets higher than those of the skilled fitter who maintained the plant. The provision of some form of incentive payment for maintenance staff was a problem which had so far completely baffled him, and in these days of full employment the only solution had been the payment of a time rate rather higher than the standard trade rate, with careful supervision and allocation of overtime. A really first-class fitter was becoming a rare bird. In the words of THE ENGINEER, such men were not scientists, they were rather artists, since a science was something one learned intellectually, whereas an art was something one learned by doing. It took years to make an efficient maintenance man with the essential qualities of initiative and "know-how," and the whole efficiency of a production plant was often nearly entirely in the hands of the maintenance personnel.

Mr. Leslie N. Duguid said that Her Majesty's Inspectors of Factories paid roughly a quarter of a million visits to factories every year. They had reported to them, in round figures, 200,000 accidents every year and 500 cases of industrial disease. Thus, in the thirty years during which he had been a Factory Inspector, there had been reported to the Department something like six million accidents. He therefore felt entitled to say that one of the conclusions to which the Factories Department had come as a result of their inspections and investigations of accidents was that a maintenance department of a very high standard was absolutely essential in a factory. The paper dealt in the main with the maintenance of production machinery. The principal purpose of the existence of a factory was to produce goods. It was, however, important to realise that a machine without an operator was just as useless as a machine which had broken down. The point which he wanted to make in the discussion was that the maintenance department of any works did in fact play a very large part in the prevention of accidents, the prevention of industrial diseases and the promotion of general good health among the workers. He did not think that that was said often enough, because he did not think that people in general appreciated what engineers and maintenance workers did. He felt that engineers should take much more credit for the work they did in the installation of plant for health and safety, and that the maintenance department was also entitled to its share of the credit for what it did in ensuring the effective maintenance of plant. With regard to some of the plants, there were legal requirements that periodic examination should be made, and this periodic examination was often done by surveyors from outside the factory. It was perhaps desirable that this should be so, but it would be a great mistake to suppose that safety could be assured simply by these statutory examinations. A good maintenance service inside the factory, in addition to those examinations, was most essential.

Mr. G. C. Allfrey said that preventive maintenance should be so organised that a machine was taken out of production only at the longest possible intervals which enabled it to be kept in the best possible order. That was usually a question of a compromise between when the maintenance man would like to take it out of production and when the production man would prefer it to be taken out. The production man generally wanted to keep it longer in production than the maintenance man did. In practice, it would be found that the proper frequency and scheduling of maintenance items in a production plant could only be arrived at after considerable experience and after the keeping of records for a considerable time. The recording and paper work was an absolutely essential part of preventive maintenance, and except in a very small works, where a man might be able to keep the details in his head (and some people were wizards at doing that), it was essential to have such records before one could say that preventive maintenance existed in a factory. The maintenance engineer should constantly review the period at which he took a machine out of production for preventive maintenance and also the amount of work he did on it when he took it out of production. He might then find, as a result of experience, that his first shot had been too elaborate and that he could in fact do a smaller job, take it out of production for a shorter time and still give just as good service. On the other hand, it might be found that, as the machine grew older, it might be necessary to take it out for preventive maintenance more frequently. Thus it was obvious that continuing records were essential for an adequate preventive maintenance scheme.

Mr. Colin Troup, B.Sc. (Eng.), A.M.I. Mech.E., said that he had been a member of a specialist team on plant maintenance which had visited America in January and February of this year. There were three points which he wished briefly to emphasise, based partly on the visit to America and partly on his own impressions. The first matter was the rather loose use of the term "preventive maintenance" or "preventative maintenance." The team had given this matter very careful thought and had come to the conclusion that there were really four stages of maintenance—breakdown maintenance, schedule maintenance, planned maintenance, and full preventive maintenance. He had not time to go into the details of those definitions, but he rather suspected that in the paper, in some instances, the author, when referring to preventive maintenance, was referring only to scheduled maintenance. He thought there was a danger in trying to give the impression that preventive maintenance was something that could be achieved overnight and that engineers might try to sell it to the management on that basis. As Mr. Allfrey had said, it was a matter of collecting data over a period of years and it was not a thing that could be rushed at and achieved overnight. There was one point which the author did not mention in the paper and which he considered to be important, namely, the question of collaboration between the maintenance engineer and the designer of the plant. A great deal could be done during the design stage of a production plant to design that plant for ease of maintenance, so as to cut down the time necessary to carry out maintenance operations and also actually to reduce the number of maintenance operations necessary over a period of time.

High-Speed Salient Pole Water Wheel Generators

A paper on "The Design of High-Speed Salient Pole A.C. Generators for Water Power Plants," by E. M. Johnson, M.Sc. Tech., M.I.E.E., and C. P. Holder, B.A., A.M.I.E.E.,* was presented to the Institution of Electrical Engineers on Wednesday, March 26th. The paper gave a critical survey of the design of salient pole generators for the 300 r.p.m. to 1000 r.p.m. range, with normal peripheral speeds of 15,000ft per minute and over, and runaway speeds of double that figure. The following abstracts from the paper are concerned with the design of the pole fixing, damper windings, limits of output, and flywheel effect.*

SALIENT poles for the larger machines in the range considered in this paper attain large dimensions; e.g., generators now being manufactured have poles and coils more than 8ft long, 2ft wide and 1ft deep, weighing about 3 tons. The centrifugal force on such a pole and coil at the turbine runaway speed may exceed 3000 tons. The design of the salient pole, its attachment to the rotor body, the construction and support of the field coil, and the design of the rotor body itself constitute the major problems of this type of machine, of which the dimensions are large in spite of improvements in the utilisation of materials.

The reason for limiting the scope of the paper to generators having a peripheral speed, under normal working conditions, in the region of 15,000ft per minute, is twofold. In the first place, it is only at this level of peripheral speed that stresses due to centrifugal force begin to have a determining effect on the design. Secondly, by the choice of 15,000ft per minute as the lower limit of peripheral speed the segmental type of rotor construction is excluded from consideration. The latter construction belongs essentially to the large-diameter low-speed class of generator and has already been discussed.[1] At the high peripheral speeds now in question the possibility of employing the segmental rim construction is only of theoretical interest, since the generator outputs obtainable with rotor diameters inside normal transport limits greatly exceed the largest water turbine outputs so far attained, or contemplated within the foreseeable future.[12]

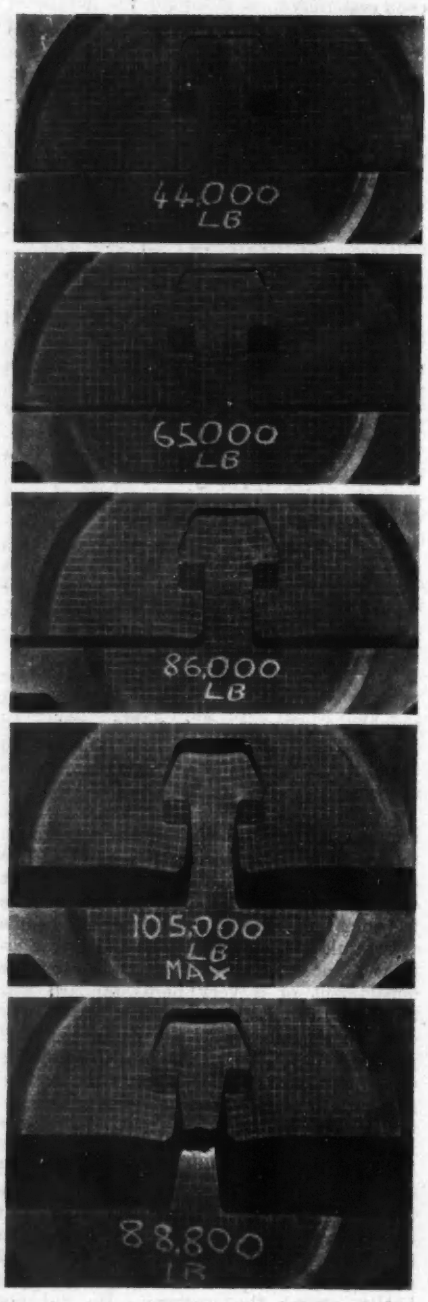
The paper does not deal with the special problems peculiar to four-pole machines. Critical speed is so much a determining factor in their design that they may be regarded as a separate class intermediate between the salient-pole and the cylindrical-rotor machine. They have a relatively low specific output and are therefore used only in exceptional circumstances.

POLES

Generators of the size considered have relatively large radial air gaps, measuring at least two-thirds of the width of the stator slot. Solid poles may therefore be used without causing undesirable pole face losses. The solid pole, either cast or machined from a forging, has an advantage over the laminated pole, since it results in a more uniform distribution of centrifugal force along the length of the pole and rotor body. The intensity of such force in the case of an average laminated pole is about 60 per cent greater at the ends than in the middle. Larger rotor diameters are therefore practicable with solid poles for the same limits of stress, and larger outputs are in consequence obtainable. Solid poles are generally more costly; they may obviate the need for a damper winding, but the principal use of solid poles for this class of machine will be to extend the permissible limits of output (see page 513).

The method of attaching the poles is of great importance, since, with rotor bodies built up of solid discs, the limiting stress usually occurs in the pole fixing. This contrasts with the segmental type of rotor used for large low-speed generators, in which the limiting stress is usually the hoop stress in the rotor rim.

The two most common methods of attaching the poles to the rotor body were described briefly in the authors' previous paper.[1] Both methods involve the provision of suitably shaped projections on the base of the poles which engage with slots machined in the periphery of the rotor body. In one case the projection is of dovetail shape and is pressed with a slight interference fit into the slot; in the other case the projection is a loose fit in the slot and is secured by tapered keys driven from the ends. The latter construction has the advantage of facilitating assembly and removal of the poles. The projections are conveniently in the form of T-heads, and there may be from one to four of them per pole.



Cross section of neck	1·25in × 1·5in
Elastic limit	24,000 lb/in²
Ultimate tensile strength	59,000 lb/in²
Elongation on 2in length	45 per cent

FIG. 1—*Tensile Test on Typical T-Head*

Various manufacturers have carried out experiments on the strength of pole fixings,[2,3] but comparatively little has so far been published in regard to T-heads. Five stages in a tensile test of a typical T-head are shown in Fig. 1, whilst Fig. 2 shows the corresponding load/extension curve. The approximate distribution of stress, for a similar T-head, is shown in Fig. 3. The stresses have been obtained from photoelastic tests (see Fig. 4) and are expressed as multiples of the average stress in the neck. It will be seen that the maximum values of local stress (which depend to a large extent on the radii of the fillets) greatly exceed the average stresses. Reference to Figs. 1 and 2 shows, however, that even when the average neck stress is at the elastic limit of the material (45,000 lb per square inch load) there is little evidence of strain at the points of maximum local stress. Furthermore, it is interesting to note that failure of the T-head occurred in the neck [see Fig. 1 (*c*)] and not in the highly stressed regions of the fillets.

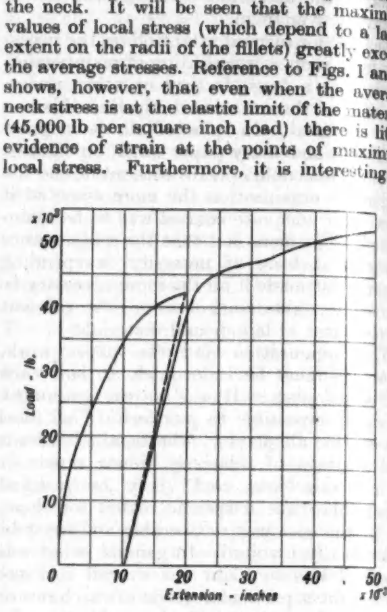


FIG. 2—*Load/Extension Curve for T-Head Shown in Fig. 1*

An alternative to dovetails or T-heads is the "comb" construction used by some manufacturers, in which projections on the underside of the pole interleave with corresponding rings formed by machining circumferential grooves in the rotor body. The centrifugal force on the pole body is taken by tightly fitting axial bolts in shear. In a recent variation of the design[4] the interleaving takes place within the pole tip, which is made deeper than normal in order to accommodate the axial bolts.

There is little to choose, on the score of strength, between the different methods of attaching the poles. From the point of view of convenience, both for the manufacturer and for the user, the advantage would seem to lie with T-heads and tapered keys. As regards cost, generalisations are impossible since custom may make a method of construction more advantageous for one manufacturer than for another. Here again, however, what consensus of opinion there is would seem to indicate a balance in favour of T-heads.

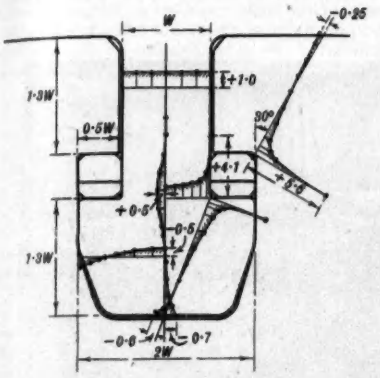
DAMPER WINDINGS

Reference was made previously[1] to the factors which influence the choice of damper windings for large low-speed generators. Similar considerations hold good for high-speed machines. A low-resistance squirrel-cage damper winding is desirable for unbalanced or rectifier loads, and to give the maximum possible pull-in torque for resynchronising after a disturbance. It also reduces to a minimum the transient over-voltages which may occur owing to an unbalanced short circuit and which might otherwise attain dangerously high values, particularly if the generator is connected to a long transmission line.[6,7] A further advantage is the damping of small pulsations of torque originating in the regulating mechanism of the prime mover. But in many cases—perhaps in the majority—a damper winding consisting of copper rods in the pole faces without a connection between poles is found to be adequate. An alternative to this is solid poles without any damper winding.[8,9] It must be admitted, however, that many generators have been built in the past with laminated poles and no damper windings and have operated satisfactorily. Such machines have the advantage under fault conditions of high negative sequence and subtransient reactance, and where fault clearance is slow there is

* Metropolitan-Vickers Electrical Company, Ltd.

something to be said for them. But with modern switchgear and protective systems, the low-resistance damper winding, whether connected between poles or not, is, on the whole, to be preferred.

Damper rods are usually distributed uniformly across the pole face; but sometimes they are omitted from the pole tips, the span of the rods then covering rather less than the width of the pole body.[10] This has the advantage, especially important in high-speed machines, of reducing stress concentrations in the pole tips; it also provides, if the rods are connected between poles, effective damping in the quadrature axis, while maintaining the direct-axis subtransient reactance



Stresses are given as multiples of the average neck stress. + Tension. − Compression. Radius of fillets = 0·05W

FIG. 3—*Stress Distribution in T-Head Under Load*

and the negative-sequence reactance at higher values than are possible with a complete squirrel-cage.

The ends of the damper rods are brazed to copper ring segments which may be spigoted or bolted, or both, to the pole end plates, the necessary provision being made for expansion. Adjacent segments are joined by bolted fish-plates to form a connection between poles. For high peripheral speeds the centrifugal force on the bolted joint is opposed by a steel tie-rod attached at its inner end to the rotor body.

A special case of unbalanced loading requiring a particularly effective damper winding is the single-phase generator

Limits of Output

It is not generally realised that the seemingly large outputs of high-speed generators recently built or under construction for water power plants (Table I) mostly fall far short of what is,

TABLE I

Country of manufacture	Output	Normal speed	Peripheral speed at normal rotational speed	Runaway speed as percentage of normal rotational speed
	MVA	R.p.m.	Ft/min	Per cent
Canada } * England }	122	327	16,600	189
Switzerland*	55	333	14,400	198
England* ...	62·5	428	14,250	182
Sweden* ...	66	428	16,300	175
France* ...	80	428	16,200	180
Switzerland*	50	500	17,300	184
Germany ...	53	500	15,400	172
England* ...	36	600	15,570	182
Switzerland	30	750	16,200	184
Switzerland*	60	750	16,700	187
France... ...	10	1,000	15,100	180

* Under construction.

in fact, attainable. If the occasion arose, some of the present maximum outputs could be exceeded several fold. This is illustrated in Fig. 5, which shows the maximum outputs that could be achieved at speeds from 300 to 1000 r.p.m., with normal materials and with the methods of construction described in the paper. It is possible that outputs as large as those indicated in Fig. 5, particularly over the speed range 428 to 600 r.p.m., will rarely be required in practice, whether because of limitations in turbine design[12] or because units of such large output would be justifiable only by exceptional concentrations of hydraulic power and electrical load. Nevertheless, the curves shown may serve to correct the view sometimes held that considerable increases in output above present levels can be achieved only by radical departures from normal design; they may also be of interest since they supplement and to some extent modify previously published estimates.[4,5,10,11]

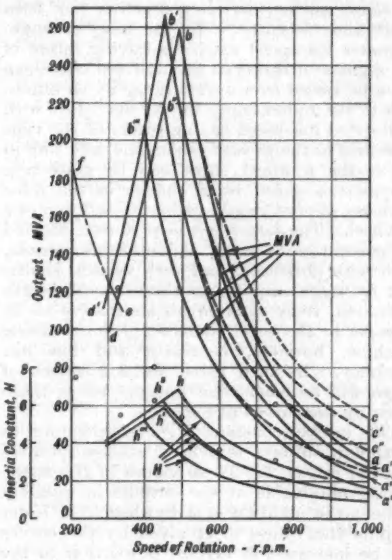
As will be seen from Fig. 5, the electrical and mechanical characteristics assumed as a basis for the output curves are in no way extreme, and the qualities of steel are those normally obtainable. The curves illustrate two points to which reference has been made earlier in the paper, namely, the effect on maximum output of using solid instead of laminated poles, and the effect of using aluminium field coils. It would be permissible to continue *ab*, *a'b'*, *a''b''*, *a'''b'''* beyond the points *b*, *b'*, *b''* and *b'''*, respectively, if stress were the only consideration. However, this would necessitate a rotor body diameter greater than 12ft 6in, which, is, in general, a limiting size both for manufacture and for transport. The curves *bd* and *b'd'* correspond to this rotor body diameter, the output, pole pitch and peripheral speed falling with the speed of rotation until a point is reached at which the stresses permit sectionalising of the rotor. The curve *ef*, although strictly outside the scope of the paper, shows how sectionalising of the rotor, by removing the transport restriction, enables the diameter to be increased almost indefinitely at constant peripheral speed, so that the limiting output rises as the speed of rotation is further reduced.

The curves *cb*, *c'b'*, *c''b''*, *c'''b'''* show to approximately what extent the output could be increased at the higher rotational speeds if the first critical speed of the rotor were allowed to be below the runaway speed. In contrast with steam turbo-generator practice, this is

FIG. 4—*Photo-Elastic Stress Pattern for T-Head Shown in Fig. 3*

usually avoided with water turbines, because the turbine speed is not under control during and after a runaway, and there is risk of the set remaining sufficiently long at or near the critical speed for resonance to build up. The necessity of keeping the first critical speed above the runaway speed involves a limitation in the length of core for a given diameter and speed of rotation. The permissible core length cannot be expressed in general terms without considerable approximation, since the critical speed depends to some extent on the dimensions and bearing arrangement of the turbine. The output curves in Fig. 5 are therefore only approximate at speeds above 600 r.p.m., and slightly higher values may well be attainable in favourable circumstances.

The use of aluminium field coils produces effects in two opposite directions. The first is an advantage resulting from the fact that, at high peripheral speeds, the centrifugal force of the pole and field coil is the determining factor in the generator design. The lower specific gravity of aluminium as compared with copper permits an increase of about 20 per cent in the rotor diameter with laminated poles and of about 13 per cent with solid poles. A corresponding increase in core length (limited by considerations of critical speed and ventilation) also results. On the other hand, the lower conductivity of aluminium leads to a loss of about



Curves	Poles	Field coils
a b d and *h*	Solid	Aluminium
a' b' d' and *h'*	Solid	Copper
a'' b'' d'' and *h''*	Laminated ...	Aluminium
a''' b''' d''' and *h'''*	Laminated ...	Copper

○ Output of machine built or under construction.

Assumptions

Runaway speed	1·8 × normal
Temperature rise	B.S. 226—Class B
Maximum core-length/pole-pitch ratio	4·5
Forged steel for solid poles and pole end-plates	30 tons/in² yield point
Rolled steel for rotor body discs ...	25 tons/in² yield point
Minimum factor of safety on yield point	1·5
Power factor	0·8
Short circuit ratio	1·0

FIG. 5—*Maximum Values of Output (MVA) and Corresponding Values of Inertia Constant (H)*

18 per cent in specific output. The gain in output due to the increased diameter and length, however, more than offsets the reduction in specific output; hence, as shown in Fig. 5, the maximum outputs obtainable with copper field coils can be exceeded, for the same limits of stress, by the use of aluminium. It should be noted, however, that whenever the required output can be obtained with copper field coils they are always to be preferred to aluminium, since the specific output is greater and the machine dimensions are therefore less. A comparison of the curves with the outputs of generators built or under construction shows clearly why little occasion has so far arisen for the use of aluminium field coils. This fact, and limitations of space, explain why no account has been given in the paper of the special problems which arise in their manufacture.

Over the portions *ab*, *a'b'*, *a''b''*, and *a'''b'''* of the curves, the outputs attainable with solid poles and with aluminium field coils can be expressed as a percentage of the output with laminated poles and copper field coils, as follows:—

	Copper coils per cent	Aluminium coils per cent
Laminated poles	100	130–140
Solid poles	160–175	175–210

Over the portions *bd* and *b'd'* of the curves, corresponding to a constant limiting diameter

of rotor body, the output with aluminium field coils is 82 per cent of that with copper field coils, owing to the lower specific output referred to above.

If the runaway speed differs from the assumed 180 per cent, the output over the portions *ab*, *a'b'*, *a''b''* and *a'''b'''* of the curves in Fig. 5 must be corrected according to the relation

$$\text{MVA} \propto \frac{1}{(\text{runaway speed})^3}.$$

Over the portions *bd* and *b'd'* the output is unaffected by change in the runaway speed.

Flywheel Effect

The importance of flywheel effect in the design of water turbine-driven generators has been dealt with recently.[1] In the case of large-diameter low-speed machines having rotors of the segmental rim type the flywheel effect can often be varied over a wide range by an alteration in the radial depth of the rim. But with high-speed machines having rotors of the type described in the present paper, the only way in which the flywheel effect can be materially increased is either by a change in the rotor diameter or core length, or by the addition of a flywheel. The latter is the preferred method for generators of small and medium outputs, both with horizontal and with vertical shafts. But for large outputs, or where overall length is limited, there is often no alternative to an increase in the rotor diameter; the resulting machine, however, is costly and has low efficiency. In such cases limiting values of stress will be reached at outputs below those given by the curves in Fig. 5.

The inertia constant *H*, corresponding to maximum output, is plotted against speed of rotation in Fig. 5. These values of *H* are the highest obtainable at the outputs in question without the addition of a flywheel. At lower outputs the values of *H* given by the curves can be increased in inverse proportion to the reduction in output.

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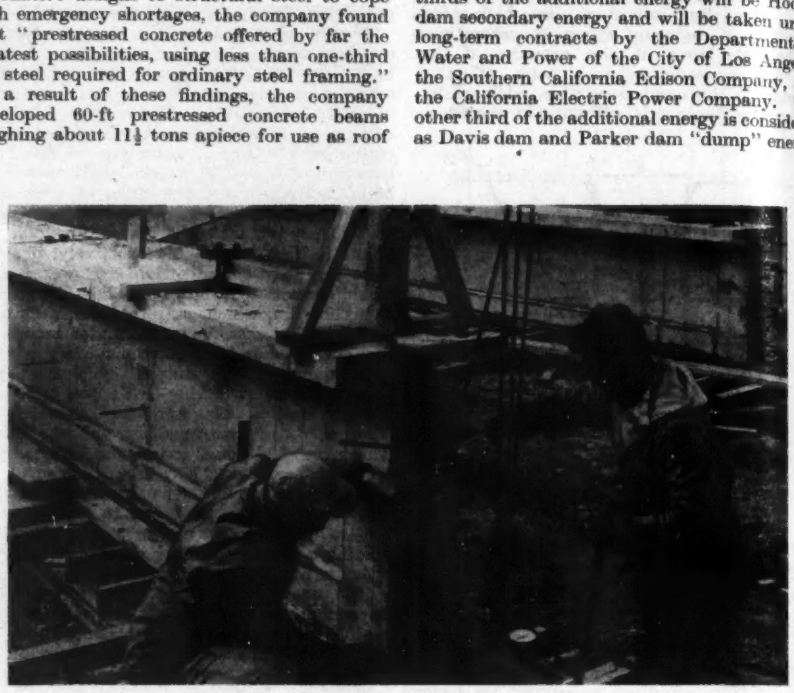
Aluminium Specifications.—The Northern Aluminium Company, Ltd., Banbury, has issued a new edition of "Specifications for Aluminium and Aluminium Alloy Products," which offers a ready correlation of the many proprietary alloy names with particular specifications, and also with one another. The booklet was first issued in 1940, and the latest issue is the fifth edition. Proprietary alloys are listed in an index and linked with British Standards and other specifications, while in the following sections the various forms in which the alloys are available are listed. The chemical composition and mechanical properties of the British Standard Specifications are given and for each specification the corresponding proprietary alloys are named.

American Engineering News

(By our American Correspondent)

Prestressed Concrete Roof Girders

The Austin Company, of Cleveland, Ohio, is now proceeding with its first industrial application of prestressed concrete construction. Following extensive investigation of alternative designs to structural steel to cope with emergency shortages, the company found that "prestressed concrete offered by far the greatest possibilities, using less than one-third the steel required for ordinary steel framing." As a result of these findings, the company developed 60-ft prestressed concrete beams weighing about 11½ tons apiece for use as roof girders in building a 60ft by 240ft addition to the works of the F. W. Wakefield Brass Company at Vermilion, Ohio. The girders contain sixty strands of ¼in diameter high-strength wire each. The wires, which have a specified minimum ultimate strength of 215,000 lb per square inch and registered a minimum of 220,000 lb per square inch under laboratory tests, were grouped in ten double cables of three wires each and wrapped in a special waterproof paper after application of an asphaltic material to prevent binding and the possibility of corrosion. The accompanying illustration shows the cables being post-tensioned to a peak of 145,000 lb per square inch by means of a 60-ton hydraulic jack. However, allowance for shrinkage and plastic flow indicated an actual working stress of 123,000 lb per square inch. Stirrups, ¼in in diameter, and spaced 12in apart in the central portion of the beam and at closer intervals within 5ft of the ends, were used to align the cables and the supplementary reinforcing, which included a number of ¼in diameter longitudinal bars along the top and bottom of the beam. Concrete with a maximum slump of 2in, and designed for a compressive strength of 5000 lb per square inch was used in the beams, which are 40in deep, with a 30in top flange and a 6in web, except at the bottom, where there is a 12in flange, 8in thick. The reinforced concrete columns supporting the beams were cast in-situ with reinforcing members, to which the beams and precast concrete struts were welded to obtain a completely integral frame. Only the 60ft girders are prestressed. The columns and the horizontal struts at the tops of the columns are of ordinary reinforced concrete, and the purlins and the girts of structural steel.



Prestressed Concrete Roof Girders

Increased Power Generation at Colorado River Dams

Expecting one of the largest Colorado River spring run-offs on record, the U.S. Bureau of Reclamation has increased power production at Hoover, Davis and Parker dam power stations in order to provide ample flood storage capacity in Lake Mead, and at the same time generate, by the end of May, about 750,000,000kWh of additional hydro-electric energy for the Pacific south-west of the United States. The additional energy, available this year because of the anticipated large run-off will benefit the customers of the Bureau of Reclamation in Southern California, Southern Nevada, and Arizona. Approximately two-thirds of the additional energy will be Hoover dam secondary energy and will be taken under long-term contracts by the Department of Water and Power of the City of Los Angeles, the Southern California Edison Company, and the California Electric Power Company. The other third of the additional energy is considered as Davis dam and Parker dam "dump" energy. Since the higher spring run-off of the Colorado River became apparent during the second week of January, contractual arrangements have been made for the disposal of this "dump" energy in Southern California to the City of Los Angeles, the Southern California Edison Company, the California Electric Power Company, and the Imperial Irrigation District. Similar arrangements have been made with power companies in Southern Nevada and Arizona.

A Magnetic Ship Models Laboratory

An interesting ship models laboratory, devoted to developing improved protective devices for ships against magnetically-exploded mines and torpedoes, has recently been put into operation at the U.S. Naval Ordnance Laboratory, White Oak, Maryland. Almost entirely automatic in operation, the equipment more than doubles the former facilities at White Oak. The major unit of the laboratory is a powerful magnetic field, which is uniform throughout a volume in space 5ft by 5ft by 10ft. Its magnitude ranges from 0 milligauss to 1000 milligauss. A less uniform but more intense demagnetising field of 50 gauss can also be produced. The field is developed by three mutually perpendicular cable loops, which are held accurately in place by wooden cable carriers mounted on the inner surfaces of the coil room. The coil is wound of special thirty-seven conductor cables distributed to produce the desired uniform field. Two additional heavy current a.c. solenoids, known as the "z-shaker" and the "x-shaker," are used to control magnetic fields at the centre of the measurement area. These shakers demagnetise or normalise the ship model before measurement. The axis of the z-shaker field is vertical, while that of the x-shaker lies parallel to the north-south directions.

An ingenious device called the model hoist and support frame places the ship model in the field at a location which is accurately known and readily reproducible. Constructed of aluminium V-channels, it is kept in the proper horizontal position at each end by vertical guide rods

which telescope into aluminium tubes. A ½ h.p. d.c. motor raises and lowers the frame. Adjustable cross-bars are mounted on the support frame and the ship model is suspended from these "yoke-bars." One end of each bar rests in a V-block to assure east-west alignment while the other end rests in a gear tooth fixture for north-south location. The field detection equipment is moved in three directions at adjustable constant velocity, and is located with an accuracy of 0·010in by an automatic translator. The longitudinal carriage moves on rails in the north-south direction; the transverse carriage moves in the east-west direction on rails mounted on top of the longitudinal carriage; the vertical tower mounted on the transverse carriage moves in the vertical direction and carries on its top surface the magnetic field detector. The source of power is a ½ h.p. d.c. motor which is coupled to a 90 : 1 reduction gear. In turn, the reduction gear is coupled to a ratio gearbox which determines the ratio of the speed and direction of rotation of the longitudinal and transverse drive shafts. The gearbox drives two 23ft long drive shafts, through drive spiders and twin-disc clutches. A clutch synchroniser opens and closes the twin clutches through cam-operated levers as the gear cluster is moved from position to position by the rotation of a lead screw. In all, there are five different positions of the cluster.

The rotation of the drive shaft is transmitted to the magnet room through bevel gears, vertical shafts and a second set of bevel gears. The latter are geared to two drive sprockets, which pull roller chains to give translatory motion to the carriages. The delivery of power to the longitudinal carriage is simple but the delivery of power to the transverse carriage is complicated. The transverse chain passes under an idler sprocket mounted at the bottom of the longitudinal carriage, over a power sprocket and down under a second idler sprocket, and then out to the return sprocket at the far end of the rail system. Rotation of the power sprocket is transmitted, through a short shaft, and bevel gears, to a drive sprocket at one end of the longitudinal carriage. As it pulls a third loop of roller chain, the drive sprocket causes the transverse carriage to move in an east or west direction. Since the motions of the two carriages are interlocked, it is necessary to predetermine their relative direction and velocity to obtain the desired resultant motion or path of the detector in the horizontal plane of 0 deg., 30 deg., 45 deg., 60 deg. and 90 deg. from magnetic north. The ratio gearbox performs this function. One of the carriages is locked or pinned in place for the 0 deg. and 90 deg. paths. This is done with pairs of remotely-controlled "pin-in" mechanisms, which drive tapered pins into precision-cut slots along the edges of all rails. The midget motors used for this device are known to be magnetically "invisible" to the detector at a distance of 20in and have been placed accordingly.

Development of Pure Vanadium Metal

As part of a recent symposium on rare metals held by the American Electrochemical Society, several interesting papers were presented dealing with the production, properties and engineering applications of pure vanadium metal. E. D. Gregory, of the Westinghouse Electric Corporation, described work conducted by that company on the production of ductile vanadium by the calcium reduction of vanadium trioxide. The starting materials used in this vanadium preparation were the oxide, V_2O_5, distilled calcium metal, and calcium chloride having a purity of 99·5 per cent. The first step is the reduction of V_2O_5 to V_2O_3 at 600 deg. Cent., in hydrogen. The reaction is relatively fast and is conveniently carried out in a tube furnace using nickel or stainless steel boats. A brownish-black product is obtained according to the following reaction: $V_2O_5 + 2H_2 \rightarrow V_2O_3 + 2H_2O$. This product is ground to pass a 100-mesh screen and is mixed with cut calcium, approximately ¼in mesh, and powdered calcium chloride in the proportion V_2O_3, 1 mol; calcium 6 mols; and calcium chloride, 1 mol. The charge is then placed in an iron container. This container is lined with calcium or magnesium oxides to prevent iron contamination during the reduction cycle. The charged container is supported inside a Vycor bulb. The latter rests on a tubulated brass plate to which it is sealed with vacuum wax. The Vycor bulb is then evacuated and 99·7 per cent argon gas admitted to a pressure of about 0·8 atmospheres, and the stopcock closed. The charge container is heated by high-frequency coils surrounding the Vycor cylinder. After the reaction mass has fired the container is maintained at approximately 1000 deg. Cent. for one hour, which is sufficient to complete the reduction. When cold, the charged container is removed and leached with 40 to 50 per cent acetic acid. After this reaction is complete the vanadium powder is washed and recovered by filtration. The overall yield in these Westinghouse experiments was 80 to 85 per cent. Ingots of vanadium may be formed by pressing the powder in steel dies at pressures of 15 to 20 tons per square inch, and then sintering in vacuo. It is desirable to sinter the powder directly to maximum density by heating up to 1400 to 1500 deg. Cent. for one to two hours. Vanadium produced by this method may be fabricated into ductile wire or sheet.

A. B. Kinzel, of the Electro Metallurgical Division, Union Carbide and Carbon Corporation, discussed work conducted at the company's research laboratories to develop a process for producing ductile vanadium that could be adapted to operation on a reasonably large scale and which would give a product of quality sufficient for ready fabrication. Ductile vanadium metal has now been consistently produced within the following chemical limits:

	Per cent
Oxygen	0·05 to 0·12
Hydrogen	0·001 to 0·004
Nitrogen	0·02 to 0·04
Carbon	0·03 to 0·07
Vanadium	99·9 to 99·8

Within these limits, yields have been consistently greater than 90 per cent and the metal produced has been found suitable for either working or remelting as required. The product is described as essentially a solid mass of crystalline vanadium; it is termed "massive vanadium" to differentiate it from ingot metal. Massive vanadium may be remelted by using a tungsten arc in an argon-cooled atmosphere and a water-cooled copper mould. This method does not differ much from that now used industrially for molybdenum and certain other metals with which the process has proved commercially practicable. The massive vanadium or the argon-arc-melted ingot may be hot worked with or without protective sheaths. Surfaces of unsheathed masses or ingots are conditioned by machining or grinding before working. Rolling or extrusion without sheathing requires a protective atmosphere. This method is recommended only when sufficiently large quantities of metal are involved. Sheathing is considered the preferred method for small-scale industrial operations. Stainless steel is the preferred material for the sheath because its hot-rolling characteristics more nearly match those of the vanadium. The sheath is fabricated by helium-arc-welding pieces of stainless steel, generally about ¼in thick, so as to make a tight-fitting box around the ingot. The optimum initial breakdown temperature has been found to be 2000 to 2100 deg. Fah. Once the ingot is broken down, the hot working temperature may vary from 1475 to 2100 deg. Fah. In general, rolling practice with respect to passes and reduction follows that established for austenitic stainless steels. Since, in the case of vanadium, there is no discontinuity in effect between hot and cold rolling, the rolling operation may be continued right down to room temperature. For various practical reasons, however, 1100 to 1300 deg. Fah. is recommended as a good finishing range. After rolling, the sheath is removed by slitting and peeling. Depending on rolling conditions used, it may be desirable to remove about $\frac{1}{16}$in from the surface of the rolled vanadium to make sure no iron or other elements from the sheath are present on the surface.

In making vanadium sheet or foil, the most common practice is to hot work down to about ¼in thickness. This is followed by cold working to produce the final article. Vacuum or inert gas annealing at 1650 deg. Fah., for one hour, is required to prepare the hot-worked material for subsequent cold rolling. It is recommended that the hardness of the surface to be cold worked should be less than Rockwell B-85. As vanadium does not work harden appreciably even during cold working, the procedures for cold working are not critical. A total reduction of 85 per cent can be made without intermediate annealing, but in so doing the hardness may reach Rockwell B-90 to 100. An increase in malleability of vanadium has been observed on heating from room temperature to about 575 deg. Fah. Since the oxidation of vanadium does not take place below 575 deg. Fah., there may be advantages in cold rolling the metal between 400 and 600 deg. Fah.

In fabricating the metal produced by the Westinghouse method, initial breakdown was accomplished by heavy passes to give about 25 per cent reduction in area, the metal being heated in argon to 600 deg. Cent. between passes. However, there is reason to believe that use of argon may not be necessary up to this temperature because only mild surface oxidation appears to occur. Rolling is continued with gradual reduction in draughts to a minimum of 10 to 15 per cent per pass until annealing becomes necessary, usually at about 50 per cent total reduction in cross-sectional area. The metal may be completely annealed by heating in vacuo at 850 deg. Cent. for one hour.

Tests have shown the machinability of pure vanadium to be about the same as that of cold-rolled steel. The metal is free cutting. Tools such as those used for copper with a high rake angle of about 15 deg. and a sufficient clearance angle of 7 to 15 deg. have been used successfully. To produce a good surface finish, high cutting speeds and light cuts are recommended. A light lubricant improves the quality of the machined surface. Vanadium may be bent, stamped and pressed using conventional methods. Vanadium may also be welded, using argon shielding. Annealing after welding is not necessary; however, stress relieving at around 1100 deg. Fah. in an inert atmosphere may be used to ensure dimensional stability.

The physical properties of vanadium metal, as is the case with some of the other rare metals, have been found to vary with oxygen, nitrogen, and carbon contents. The amount of cold working also affects the properties of the metal. The hardness varies from Rockwell B-75 to C-29, and can be fairly well controlled within these limits. The amount of gases, such as oxygen and nitrogen, in solid solution has a pronounced effect on hardness, ductility and tensile strength. In general, these gases result in increased hardness and tensile strength, and decreased ductility. The only satisfactory method for determining oxygen in vanadium appears to be the vacuum fusion technique. The density of vanadium is appreciably lower than that of steel and the elastic modulus is relatively high for that density. The modulus-density ratios for steel and vanadium are practically equivalent (3,700,000) and higher than that for titanium, which is variously given as 3,100,000 to 3,600,000. From this comparison, indications are that, other things being equal, vanadium would be the first choice for a structural part in which flexural rigidity was the determining factor. This and data on static tensile properties indicate that vanadium should make a particularly good spring material. Data on vanadium produced by the Westinghouse method show an ultimate tensile strength of 100,000 lb per square inch for annealed vanadium and 140,000 lb per square inch for the work-hardened metal. The corresponding hardness values were reported to be 230 Vickers Pyramid Hardness Number for the annealed and 330 for the work-hardened metal. The corresponding elongation for fully-annealed samples of 0·10in diameter and 0·5in gauge length was 23 per cent; for the work-hardened material, 0·05in diameter and 0·5 gauge length, 3 per cent. Such figures for tensile strength and elongation relate to metal containing appreciable oxygen and nitrogen. As the purity of

the metal improves, a considerable drop in tensile strength and an increase in elongation may be expected. Corrosion tests have shown that vanadium is resistant to pitting and corrosion by sea water and salt spray. This resistance, in view of the high elastic modulus and the negligible magnetic susceptibility of the metal, might well lead to interesting applications in instruments and dynamic stress-carrying parts to be used on board ship or in salt water atmospheres.

Road Research in 1950

THE Road Research Board of the D.S.I.R. has now published the report of its activities during 1950. As with previous reports, the subject matter is of considerable interest to all of those concerned with the road. The work is divided into two main divisions, namely, "traffic and safety" and "materials and methods of construction." Some brief notes on the matters discussed in the report are given below.

Vehicle Brakes.—Measurements of the braking performance of a random sample of cars in use on the road showed the need for better maintenance of brakes. A car with brakes in first-class condition can be stopped on a non-skid surface in about 45ft from 30 m.p.h., but less than 10 per cent of the cars on the road can stop in this distance; 50 per cent of the cars require a distance of 75ft to stop from 30 m.p.h., and 10 per cent require at least 100ft. These distances do not include any allowance for the "reaction time" of the driver. A quick-witted driver has a reaction time of about two-fifths of a second, but for the average driver it is three-fifths of a second or more. Thus the average driver in the average car requires a distance of at least 100ft to stop from 30 m.p.h.

Vehicle Lighting.—Inadequate tail lamps are a serious danger to traffic at night. A survey showed that 2 per cent of commercial vehicles and 12 per cent of cyclists were without rear lights at night, and that many other vehicles had rear lights of very low intensity. A substantial contribution to road safety could be made, it is stated, by ensuring adequate rear lighting.

Accident Analysis.—Analysis of accident statistics, taken together with sample counts of traffic using the roads, showed that on the average a pedal cycle or motor-cycle combination is more than twice as likely to be involved in a personal injury accident as a car for the same distance travelled. Solo motor-cycles are four to five times as likely to be involved. On roads with no speed limit the proportion of motor-cycle accidents in which skidding occurred was highest for solo machines with pillion passengers and lowest for combinations.

Investigations into other factors affecting accidents and traffic flow, such as the degree of curvature of the road, are given in the report.

Traffic Trends.—On a number of sample counts motor traffic using the roads in 1950 exceeded by 8 per cent the traffic in 1938. The average journey speed of traffic in Central London during the busy hours was measured in a number of test runs as 10·9 m.p.h., 0·5 m.p.h. less than in the previous year.

Road Engineering.—It is now possible to predict, before a new road is built, the value to which the moisture content of the soil beneath it will tend. The subgrade or embankment should be compacted while its moisture content is at or near this value. Subsequent shrinkage or swelling can thus be reduced to a minimum. Progress has been made in stabilising heavy clay soils; one such soil has been successfully stabilised with cement. A prestressed concrete road constructed by the Crawley Development Corporation has been studied by the Laboratory staff, and the experience gained, it is stated, will assist in the design of future roads of this kind.

New binder distributors now on the market incorporate the improvements in design which the Laboratory has been advocating. In particular the Laboratory has laid great stress on the necessity for obtaining a uniform lateral distribution of the binder. A test for this has now been developed by the Association of Road Surface Dressing Contractors, and they have set up nineteen testing stations to calibrate binder distributors. The improved design and maintenance of distributors is expected to raise the standard of surface dressing in this country and, by lengthening the life of surface dressings, greatly to reduce the cost, at present some millions of pounds a year, of this form of maintenance.

Thin surfacings laid mechanically are being increasingly used. Specifications for such surfacings need to be varied to suit local climatic conditions, and road experiments in different parts of the country are indicating the most suitable compositions with the aggregates and binders available in each area.

Further experience has confirmed that the Laboratory's rapid method for estimating the binder content of a bituminous mixture is of great value in controlling the composition of material produced by modern high-output plant. A further development makes it possible to grade the aggregate during the extraction of the binder.

The report, which is entitled "Road Research in 1950," is obtainable from H.M. Stationery Office at a price of 3s. 6d.

Canadian Water Power

THE Water Resources Division of the Canadian Department of Resources and Development has now issued its annual review of the water power of Canada. The latest available information regarding water power in each province is summarised in this review, and a brief discussion of overall resources is given under such divisions as provincial distribution, current progress in development, growth of development, general utilisation and relationship of development to population.

The recorded water power resources of Canada are now shown as totalling more than 29 million horsepower under conditions of low stream flow and 50 million horsepower at average flow, the latter figure representing a feasible turbine installation of over 65 million horsepower. The total turbine installation at the end of 1951 is given as 13,342,504 h.p., indicating that only slightly more than 20 per cent of the available resources have been developed. During 1951, hydro-electric construction was very active with 881,250 h.p. of new capacity coming into operation and with good progress being made on other new developments.

Of the 13,342,504 h.p. comprising the total Canadian capacity, 6·5 per cent consists of power developed directly for pulp and paper companies for their own exclusive use; 4·5 per cent corresponds to similar installations in other industries, and the remaining 89 per cent is classified as "central electric stations," i.e., power stations which generate power for sale. Nearly 97 per cent of all the electricity produced by "central stations," for sale in Canada or for export to the U.S., is generated from water power, the hydraulic production in 1951 being 55,570 million kWh. In 1950, the figure was 49,077 million kWh.

Of the 6·5 per cent of Canadian installations owned and used by the pulp and paper industry, about 50 per cent deliver mechanical power by direct drive. Under normal conditions, the industry is also the largest industrial purchaser of electric power from "central stations." An appreciable part of the purchased power is of the secondary or off-peak class and is used for steam-raising in electric boilers; however, owing to the current heavy demand for primary power, the amount of available secondary power is much lower than in the pre-war period. The overall consumption of the industry represents about 24 per cent of the total power output of the country.

The installed capacity of water power plants in Canada now equals 952 h.p. per 1000 of population.

French Engineering News

(By our French Correspondent)

The National Institute of Economics has published interesting statistics showing the electricity position in France. The Lyons area has the highest consumption, and 99 per cent of industries, commerce, artisans, &c., use electric current. The Paris area comes next with 98 per cent. In the Centre of France 97 per cent of industry uses electricity; the West is the smallest consumer with 84 per cent. Other statistics show that in towns with 100,000 to 150,000 inhabitants electricity is used by almost 100 per cent of the inhabitants. In towns over 150,000 it averages about 98 per cent. In very small towns from 2000 to 5000 some 99 per cent of the population use electric current. It is therefore estimated that if the present electrification plan is completed by 1953, the consumption potential will be met completely. Any further growth of consumption in France would then be due to increased loads on existing installations. On the other hand, France will be able to pay greater attention to the export of electricity.

* * *

Very little has been written about the development of uranium research in France. Nevertheless, the Commission for Atomic Energy has continued its researches and has announced that at La Crouzille, in the Haute Vienne, production of minerals has reached an industrial level. Some twenty-five miners, using mechanical methods, are employed, and the mineral is said to be ten times richer than that mined in the United States. One of the chief characteristics of the pitchblende mined at La Crouzille is its purity. It contains iron pyrites, which, because of the difference in density, is separated by mechanical methods. Thus, no chemical process is necessary, and the cost is small. It is reported that the seam is about 12cm thick, although at greater depths it splits up into thinner seams. It is estimated that several hundred kilogrammes of uranium can be extracted per square metre. Because it is rich, particularly near the surface, the number of miners needed to work the seams is relatively small. At Grury a 200m shaft has been sunk. It is expected to produce some interesting results shortly. Small quantities will also be mined at Lachaux. In Madagascar a seam of uranium phosphates has been found at Vinanin-Karena. A flotation plant for separating the mineral is to be constructed there, and it is hoped that work will begin in the autumn. Research is also being carried on in Equatorial and West Africa and in Morocco.

* * *

The Mining Research Bureau of Morocco has announced that its programme for 1952 will include an extension of the workings of the Djerada coal seams, and an increase in the extent of the copper mining in the Atlas Mountains. Some 360 million francs will be spent on extensions throughout the year.

* * *

Not including the Saar territory, some 8,125,000 tons of cement were produced in France in 1951, as against 7,208,000 tons in 1950. This is an increase of about 12·7 per cent and is a record figure. The most favourable period in the life of the industry, until last year, was from 1930 to 1932, when production reached 6,300,000 tons. In 1938 only 3,787,000 tons were produced. It is pointed out that for many years the industry was working to only half of its capacity, owing to the economic crisis, and that after the war material shortages not only hindred production, but made the upkeep of plant extremely difficult. The success of the industry last year, therefore, is considered to be highly satisfactory.

* * *

French Railways is now building a 104m, single-span bridge at Valenciennes, across the Escaut River. The bridge is being constructed by the Cie. Fives Lille. It will replace a temporary structure which has been in place for eight years.

Industrial and Labour Notes

The Steel Scrap Drive

In its annual report for 1951, the British Iron and Steel Federation stated that, as a result of the scrap drive which was carried on intensively throughout the year, the extra amount of scrap forthcoming was about 325,000 tons. That quantity was raised mainly from within the steel industry itself, and the comment made in the report was that it was impossible "to avoid the conclusion that steel users have made nothing like the same effort as the steel makers themselves to throw out all possible supplies of scrap."

This year the scrap drive is being further intensified, and already there are signs that it is producing more encouraging results. In the first ten weeks of 1952, deliveries of home-bought scrap averaged 75,300 tons a week, compared with 72,900 tons weekly in the corresponding period of 1951. This result has been achieved in spite of a decline from 4700 tons a week last year to 2300 tons a week this year in the quantity of shipbreakers' scrap becoming available. There is some improvement in the imported scrap situation, although the prospects are by no means favourable. It is hoped, however, that from foreign sources it may be possible to obtain 400,000 tons or so this year. The British Iron and Steel Federation is able to feel, however, that the drive for more scrap is yielding worthwhile results—and at a cost per ton for publicity and administration which is remarkably low. Industrial steel consumers are becoming more and more "scrap minded," although up and down the country there are doubtless many tons of scrap in the form of obsolete capital equipment, spares, tools, and so on, which could be disposed of readily. The district scrap committees, which cover every area of the United Kingdom, will gladly give advice and information.

Iron and Steel Production

This country's output of steel ingots and castings averaged 320,200 tons a week during March, which represented an annual production rate of 16,648,000 tons, compared with an annual rate of 16,281,000 tons in February, and 16,546,000 tons in March last year. It should be borne in mind, however, that the Easter holiday fell in March, 1951. In the first quarter of this year, steel output was at an annual rate of 15,991,000 tons, as against a rate of 16,425,000 tons in the first quarter of 1951. Pig iron production in March, which averaged 201,500 tons a week, was the highest yet achieved, the annual rate being 10,478,000 tons. In March last year, pig iron output was at an annual rate of 9,572,000 tons, and over the first quarter of this year the annual production rate has averaged 10,355,000 tons.

In circulating these figures, the British Iron and Steel Federation has stated that supplies of coke are still inadequate to meet the needs of the blast-furnaces. Coke stocks have been drawn upon at the rate of 2000 tons a week during March, and the total stocks on the ground at the blast-furnaces now represent only four days' supply, which is less than the safe minimum. This must be compared, the Federation says, with a programme figure of at least three weeks' stock held by other coke users. Further increases in pig iron production are essential if steel output is to reach even last year's level. The necessary expansion of pig iron output will be assisted by three new blast-furnaces which are due to come into operation this month and next. But, the Federation points out, after allowing for two old furnaces which will go out of operation, and an increased use of home ore generally, pig iron output in this country could be increased by a further 300,000 tons a year provided additional coke is available also at the rate of 300,000 tons a year. Arrangements to bring the new furnaces into blast cannot therefore be completed until at least 6000 tons a week of additional coke are assured.

The steel industry's development plan is based on a supply of purchased coke from the National Coal Board and other ovens of 76,000 to 77,000 tons a week, which was the tonnage of purchased coke supplied in 1948 when the forward coke plans were made. At present, the Federation comments, in spite of some increase in the National Coal Board's total coke output, deliveries of purchased coke to the iron and steel industry have fallen to an average of about 70,000 tons a week. Unless, therefore, this shortage in purchased coke supplies can be overcome, the Federation fears that pig iron output will be held back and steel production will be below last year's level.

The Excess Profits Levy

The Association of British Chambers of Commerce has submitted to the Chancellor of the Exchequer a report on the Excess Profits Levy which has been made by its Finance and Taxation Committee. After studying the report, the Association's Council is unanimously of the opinion that the levy should be dropped "because it is likely to do more harm than good in the present economic situation of the country."

In the report it is suggested that there is no economic case for the excess profits levy. The broad financial policy to strengthen sterling, it is stated, depends on unusual efforts to increase the manufacture and sale of goods. That policy, the report continues, is based on increased income from exports, on increased production, and on a considerable increase in overseas invisible exports from shipping and other services, and to levy a special tax on the increase is scarcely the right way to promote it. In the Association's view, the terms of seeking new business are that, if it fails, the venturer bears the whole loss, whilst if it succeeds, four-fifths of the profit are absorbed by taxes and one-fifth remains to the venturer. The levy, it is claimed, runs contrary to the general purpose of the Government's financial policy.

The report goes on to say that to believe that excessive profits can be made out of munitions work is to ignore the tightness of the control over contracts and the methods of costing Government contracts, which preclude more than a modest remuneration for the work. The excess profits levy, like the profits tax, the report adds, will be, in simple terms, a transfer of company past savings to Government savings, and business will be left to borrow or raise new capital to finance its business assets and stocks. With credit restriction as part of the same financial policy, the result can only be a contraction of business activity with all that follows from it.

Opencast Coal

The National Coal Board has now taken over from the Ministry of Fuel and Power full responsibility for opencast coal production in Great Britain. An "opencast executive" has been established consisting of five members, two of whom are members and three officials of the National Coal Board. Mr. W. J. Drummond is the chairman of the executive, the other members being Sir Andrew Bryan, Mr. H. R. Warburton, Mr. F. C. Baker, and Mr. J. R. Caseley, who is the Board's chief civil engineer, and who has been conducting opencast mining operations under the Ministry of Fuel and Power for several years.

The National Coal Board says that in view of the need for the greatest possible output of coal, opencast production will be continued at full pressure, the same regard as hitherto being paid to agriculture and amenities. The Ministry of Fuel and Power continues, in law, to be responsible for the requisitioning of land and for consulting with other interests when requisitioning is in prospect. The agricultural rehabilitation of land after the coal has been won will continue in the hands of the Ministry of Agriculture, the only charge being that the cost will be borne by the National Coal Board instead of by the Exchequer. At present there are 126 opencast sites in operation, mainly on the North-East Coast, and in Yorkshire, the North-West, the Midlands, South Wales, and Scotland.

Institution of Works Managers

The council of the Institution of Works Managers has announced an essay competition, in which prizes of £100 and £75 in the senior and junior grades respectively are being offered. The competition is open to anyone employed in industry in the United Kingdom, within certain age limits, apart from those who may have received previously a similar award from the Institution. The subject for the competition is "What are Likely to be the Structure and Problems of Works Management in 1977."

This subject has been selected with the idea of invoking creative imagination as to how works management is likely to develop in the next twenty-five years, especially in those directions which are not strictly technical. The essays are required to be about 2000 words in length, and will be judged more by their content than by their style, although clear English is important. They will be marked in two grades, as follows: senior, to include competitors who were not over thirty-five and not less than thirty-one on January 1, 1952; and junior, to include competitors who were not more than thirty on January 1, 1952. The winner in the senior grade will be awarded the Sir Henry Fildes Medal of the Institution.

The closing date for entries in the competition is September 30, 1952. Full particulars can be obtained from the Institution of Works Managers, 67/68, Chandos Place, London, W.C.2.

Copper Prices

Following the announcement by the Ministry of Materials of an increase of £4 a ton in the selling price of virgin copper, the Minister of Supply has made an Order adjusting the prices of copper and copper alloy secondary and scrap metals. This Order, known as the Copper, Zinc, &c., Prices Order, 1952, came into effect on April 8th. It increases the maximum controlled prices of secondary unwrought copper by £4 a ton; copper scrap, gilding metal and gunmetal by £3 a ton; and cupro-nickel and brass by £2 a ton. It also consolidates and revokes earlier non-ferrous metals prices Orders.

The Monopolies Commission

The Board of Trade has made a new reference to the Monopolies and Restrictive Practices Commission. The Commission is to investigate the supply and exports of certain electric generators, electric motors and transformers, and steam and hydraulic turbines for driving heavy alternators.

The detailed list, announced by the Board of Trade, is as follows: alternators of not less than 300kW maximum continuous rating, designed to be turbine driven, and steam and hydraulic turbines for driving such alternators; other alternators of not less than 10kVA rated output; d.c. generators of output not less than 0·75kW per 1000 r.p.m., and of not less than 0·75kW actual rating; a.c. electric motors of not less than 1 h.p. at any speed; d.c. motors of output not less than 1 h.p. per 1000 r.p.m. and of not less than 1 h.p. actual rating; transformers of not less than 5kVA rated output.

The reference requires the Commission to make a report to the Board of Trade both about the facts of the matter and about the bearing of those facts on the public interest. Any person or organisation wishing to offer evidence should write to the secretary of the Monopolies and Restrictive Practices Commission, 3, Cornwall Terrace, London, N.W.1.

Notes and Memoranda

Rail and Road

NOTES ON ROADS AND ROAD TRANSPORT.—The latest publication of the British Road Federation, 4a, Bloomsbury Square, London, W.C.1, is entitled *Speakers' Notes*, 1952—*Road Development and Motor Taxation*. It contains notes for reference on the various aspects of road transport, such as the merits of motorways, maintenance, accidents, and taxation.

THE "BRITANNIA" LOCOMOTIVES.—In the final paragraph of our leader on the "Britannia" locomotives in the issue of April 4th, we said: "In consequence, the design has since been modified in two respects by plugging the hollow axles at each end for the length of the wheel fib . . ." This should, of course, have read "for the length of the wheel fit."

STATION RECONSTRUCTION.—Approval has now been given by the British Transport Commission to a scheme for the reconstruction of Potters Bar station on the Eastern Region of British Railways, and a widening which will enable four tracks to be provided where, at present, there are two. Two additional running lines will be constructed for a distance of about three-quarters of a mile, and the station will be provided with two island platforms to serve all four running lines. There will also be new station buildings, a new signalbox, and alterations to the track layout and goods yard facilities. The cost of the scheme will be in the region of £400,000.

THE CONWAY BRIDGE.—We have received from the British Road Federation a leaflet, entitled "Conway Bridge," which gives some interesting information about the need to replace Telford's suspension bridge at Conway, which was completed in 1826. The bridge has never been adequate for modern traffic—it is situated on the trunk road A.55, the normal flow of traffic being 6300 vehicles a day—and has been subject to "one way" operation, involving delays, normally, of twenty minutes for traffic passing over it. A weight restriction of 7 tons 15 cwt on traffic using the bridge, came into force on April 1st. Plans for replacing the bridge, at a cost of about £500,000, have been prepared.

Air and Water

APPRENTICES AT GAS TURBINE SCHOOL.—Ten senior Ministry of Supply apprentices have completed a special ten weeks' course arranged by the School of Gas Turbine Technology, Farnborough. The apprentices, all of whom are in the last stages of their Ministry of Supply five-year training, came from the Royal Aircraft Establishment, Farnborough; the Royal Ordnance Factory at Radway Green; the Royal Small Arms Factory at Enfield, and the National Gas Turbine Establishment. Four weeks of the course were spent at the Establishment and six at the Power Jets' school. At the end of the course the students sat for an examination which was assessed by the Ministry of Education and the Institution of Mechanical Engineers. The ten weeks' syllabus included the design of aircraft gas turbines, the design and application of gas turbines for industrial purposes, and a practical course on the maintenance and construction of aircraft gas turbines.

Miscellanea

80MVA BRITISH TRANSFORMER ORDER FOR CALIFORNIA.—An order for an 80MVA, 3-phase, 230/115kV, auto-connected transformer for the Folsom power station in California, has been placed with the English Electric Company, Ltd., by the United States Bureau of Reclamation; the value of the contract is 200,000 dollars.

SULPHUR FROM PETROLEUM.—The sulphur recovery plant which the Shell Petroleum Company, Ltd., has built at its Stanlow refinery, has been completed and is now manufacturing raw sulphur from the hydrogen sulphide by-product of the catalytic cracking unit. A sulphuric acid plant, which is in course of erection, is expected to be ready by the end of the year, and the total cost of both plants is estimated at about £500,000.

SEVERN HYDRO-ELECTRIC SCHEME.—The Minister of Fuel and Power, Mr. Geoffrey Lloyd, has stated in a written reply that further consideration of the Severn power scheme awaits the result of the experiments to determine the effect of the barrage on the Bristol Channel ports. The construction of the model for that purpose cannot be started until the building of the new Hydraulics Research Station, where the work will be done, is sufficiently advanced.

OBITUARY.—We regret to record the death, in Birmingham, on March 26th, of Mr. Horace Shankland, who until his retirement two years ago was a local director of Dunlop, Ltd. Mr. Shankland, who was sixty-nine, had been engaged in the tyre industry for fifty-two years. He was president of the Society of Motor Manufacturers and Traders in 1941. . . . We regret also to record the death of Mr. V. R. Rook, which occurred on March 29th. Mr. Rook was forty-nine, and had been on the staff of the Society of Motor Manufacturers and Traders since 1925.

NIMONIC 95.—The existence of another nickel-chrome alloy in the Nimonic series has recently been announced by the Mond Nickel Company, Ltd., Sunderland House, Curzon Street, London, W.1. It has been developed from the Nimonic 90, and named Nimonic 95. The strength characteristics of Nimonic 90 are retained in the new material, but at operating temperatures some 50 deg. Cent. higher than those previously permitted. It is stated that the material is the same class of alloy as Nimonic 90, but has an increased content of hardening elements, and although the metal is stronger and stiffer because of improved processing techniques, it can still be hot-worked and machined.

METALS FROM WASTE MATERIAL AND LOW-GRADE ORES.—The Technical Information and Documents Unit of the Department of Scientific and Industrial Research has published a bibliographical survey of information on the recovery of non-ferrous metals from waste materials and on their extraction from low-grade ores. The survey is based on German and Japanese experience in this work before and during the war, and includes a list of more recent American reports held by T.I.D.U. The report deals with mining and ore dressing and with the smelting and recovery of base metals. It also covers the production and recovery of non-ferrous metals. Sections dealing with precious metals, rare earth metals and selenium are included. The waste materials from which metals have been recovered include slags, scrap metals, waste liquors, flue dusts and spent catalysts. Grinding dust, swarf and even floor sweepings from engineering works can be treated for the recovery of scarce metals. The report, which is numbered R.M.S.–3, can be obtained from H.M. Stationery Office, price 3s. 6d.

AMERICAN INDUSTRIAL LITERATURE.—The American Library, at 41, Grosvenor Square, London, W.1, has recently opened an industrial section, which includes American books, periodicals, Government documents, and other literature in the fields of technology, engineering, management, trade and agriculture. Books and other material can be borrowed by anyone in Great Britain and, where necessary, will be sent by post. In cases where a book or periodical is not available for loan, photostatic copies of special articles will be provided free of charge. The library also answers requests for information received by telephone or letter. The library works in close co-operation with British technical libraries and specialised research agencies, and acts as liaison with appropriate agencies in the United States where information in its own collection is not sufficient. It has full access to existing special American indexes which give complete reference by subject of all articles or books published throughout the English-speaking world. The library is open to the public, Monday to Friday, from 9 a.m. to 6 p.m. Inquiries will be answered by telephoning Grosvenor 9000, extension 447 or 748.

ALLUVIAL TIN ORE.—Between 1925 and 1928 a reconnaissance geological survey of British Honduras was made by Mr. Leslie H. Ower, D.I.C., and his report, subsequently published by the Royal Geographical Society, announced the presence of small quantities of alluvial tin ore in various localities. The Colonial Office now says that in one of them, North Stann Creek, this has been confirmed recently by the work of Mr. C. G. Dixon, F.G.S., senior geologist of the British Guiana Geological Survey, who has found that cassiterite seems to be fairly generally distributed throughout that valley and that traces occur also in tributaries of Sibun River and Freshwater Creek. Pits were dug by pick and shovel, the gravels being washed by hand in a prospecting pan, and it was seldom possible to excavate to a depth greater than 4ft. No estimate has been made of the depth of the alluvium, and the examination was merely of a preliminary exploratory character in which no quantitative estimates were possible. More detailed prospecting would require pumping, drilling, or other mechanical equipment. A second examination is being made this year when it is hoped to determine whether large-scale prospecting will be worth while.

COMBUSTION ENGINEERING ASSOCIATION.—The annual conference of the Combustion Engineering Association is to be held at the Palace Hotel, Buxton, on Monday and Tuesday, May 5th and 6th. The opening session on May 5th will start at 10 a.m., and the day will be devoted to a discussion on "Fuel Supplies in Relation to New and Existing Plant." The proceedings on the second day begin at 9.45 a.m., the topic for discussion being "The Back Pressure Generation of Electricity in Medium and Small Works." Particulars of the conference can be obtained from the headquarters of the Association at 6, Duke Street, St. James's, London, S.W.1.

Personal and Business

MR. J. F. COALES has resigned his position as research director of Elliott Brothers (London), Ltd., Lewisham, S.E.13.

BOSELEY INSTRUMENTS, Ltd., formerly of 222, West Road, Southend-on-Sea, has moved to larger works at Progress Road, Eastwood, Essex.

WILKINSON MACHINE TOOLS COMPANY has moved to new premises at 38a, Station Road, North Harrow, Middlesex (telephone, Harrow 5491).

THE MINISTER OF TRANSPORT has appointed Mr. J. E. Rigby to the Transport Users' Consultative Committee for the North-Western Area.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., announces that the telephone number of its Ipswich branch is to be changed on April 15th to Ipswich 51265.

THE NATIONAL COAL BOARD states that the telephone number of its headquarters at Hobart House, Grosvenor Place, London, S.W.1, is now Sloane 3401.

MR. REX BATE, sales director of the Brush Electrical Engineering Company, Ltd., Loughborough, is transferring his headquarters to the group's offices at Duke's Court, London, S.W.1.

THE UNITED STEEL COMPANIES, Ltd., state that Mr. H. C. Butcher has retired from the secretaryship of Samuel Fox and Co., Ltd., Stocksbridge, Sheffield, after fifty-two years in that company's service. His successor is Mr. F. Stones.

MR. J. A. HUNT, general manager of the Hymatic Engineering Company, Ltd., has been elected president of the British Compressed Air Society. Mr. H. G. Harwood, a director of Hugh Wood and Co., Ltd., has been elected vice-president.

THE LONDON MIDLAND REGION of British Railways announces the retirement on April 19th of Mr. W. M. Bond, assistant (permanent way) to the civil engineer. Mr. Bond began his railway career in 1912 in the chief engineer's department of the London and North-Western Railway.

THE COLONIAL OFFICE announces the appointment of Mr. W. T. P. Perkins as chief engineer, Nigerian Railways. At present he is general manager of the Transport and Harbours Department, British Guiana, in which appointment he is to be succeeded by Mr. A. J. F. Bunning.

MAJOR-GENERAL W. S. TOPE, C.B., has relinquished the chairmanship of Henry Meadows, Ltd., Wolverhampton, which has been acquired by Associated British Engineering, Ltd. Mr. A. P. Good is now the chairman of the company, and Major-General Tope has taken up other duties in the Brush ABOE group.

Contracts

THE ENGLISH ELECTRIC COMPANY, Ltd., has received an order worth £2,500,000 from the South African Railways and Harbours Administration for sixty electric locomotives to operate on the 3000V d.c. electrified lines of the Union. Each locomotive will weigh 77 tons, will have a maximum axle load of 19·5 tons, and will be of the class "5E" double-bogie, Bo–Bo arrangement, with one-piece cast steel bogie frames. The four traction motors will develop a total of 2000 h.p. at the one-hour rating and the control provides for regenerative braking.

MIRRLEES, BICKERTON AND DAY, Ltd., has received an order from the Burntisland Shipbuilding Company, Ltd., to build the propelling machinery for a cargo ship under construction for the Currie Line, Ltd. The installation will consist of two "K.V.S. 12 G.M.R." engines having a 15in bore by 18in stroke, each developing 1955 b.h.p. at 375 r.p.m., and driving a single propeller shaft through Barclay Curle fluid couplings and a reverse reduction gearbox supplied by Modern Wheel Drive, Ltd. The final power available is 3565 s.h.p. at 116 r.p.m.

British Patent Specifications

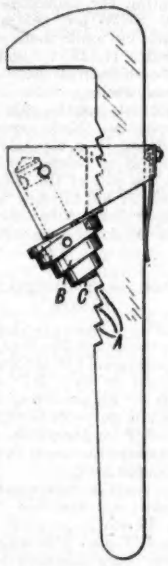
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

WORKSHOP TOOLS AND APPLIANCES

667,308. January 12, 1950.—CLAMPING DEVICES, John Garrington and Sons, Ltd., of Albert Works, The Green, Darlaston, Stafford.

The invention relates to adjustable spanners, pipe wrenches, vices and bench clamps. The construction of a spanner is shown in the drawing. In the side of the shank are formed rack teeth *A*, which are of triangular shape, the projecting apex of each tooth being a right angle. In order to retain the movable jaw in the position required a worm *B* is provided to transmit the load thrust from the movable jaw to the rack, the smaller end



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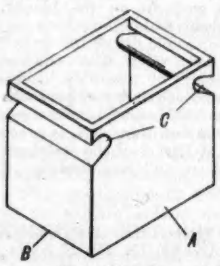
C of this worm being directed towards the rack and the axis of rotation of the worm being inclined at an acute angle to the length of the rack. Thus when the load is applied to the movable jaw the threads of the worm are pressed against the rack to resist the load thrust on the jaw. The load upon the movable jaw when the spanner is used to turn a nut tends to place the threads of the worm and the teeth of the rack in a state of compression as well as in a state of shear. In the specification the invention is shown applied to various kinds of spanners, wrenches and bench vices.—*February* 27, 1952.

668,241. February 14, 1950.—RECTANGULAR CONTAINER FOR TRANSPORT PURPOSES, Aktiengesellschaft Brown, Boveri and Cie., Baden, Switzerland.

The invention concerns rectangular receptacles which are used in workshops for the transportation of component parts and for similar purposes. The receptacle *A* has both the end walls *B* provided with a groove *C*, which extends over the full width of the wall and serves as a handle. The grooves can either be formed integrally by pressing, or U-shaped



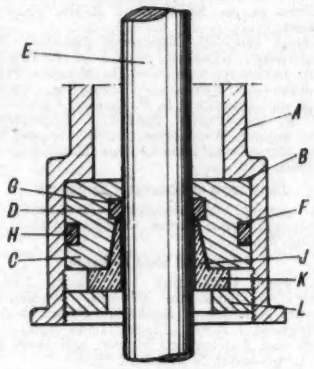
No. 668,241

sectional elements can be welded on to the wall. The built-in U-shaped elements also serve to stiffen the walls of the receptacle. The handles formed by the grooves enable the receptacle to be lifted easily and facilitate slinging from a crane, it being impossible for the crane ropes to slip out of position. The receptacles are also constructed so that several of them can be stacked according to the "building block system"; when hoisting the ropes only have to be placed into the grooves of the lowest receptacle. A further advantage of the lifting grooves is that several receptacles placed in a row with the grooves in alignment can be transported by carrying rods inserted into the grooves.—*March* 12, 1952.

SHAFT GLANDS AND SEALS

668,356. March 31, 1950.—PACKING DEVICES BETWEEN SLIDING PARTS, Olaer Marine, 53, rue la Beotie, Paris, 8°, Seine, France.

This invention relates to packing devices between a pneumatic cylinder and a reciprocating piston. In the drawings there is shown one end of a cylinder *A* provided with a shoulder *B*, on which bears a ring *C* provided with two grooves of rectangular section, an inner groove *D* adjacent to a piston rod *E* and an outer groove *F* adjacent to the cylinder. A sealing "O"-ring made of elastic material such as rubber is housed in each groove, the rings being, respectively, indicated by references *G* and *H*. The ring *C* has a conical inner recess



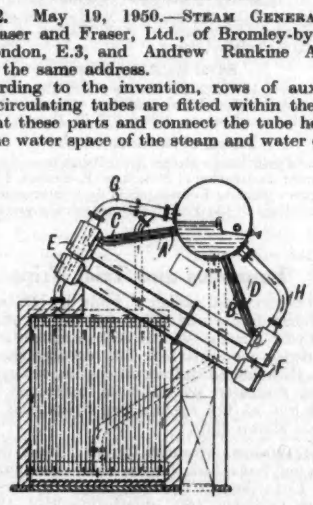
No. 668,356

extending from the groove *D* and flaring towards the base of the ring. A metal tapered sleeve *J* in this recess has at the apex of the tapered portion a resilient lip having a scraping edge folded inwards, which slides against the wall of the piston rod. The resilient lip is in contact with the inner sealing "O"-ring *F*, so that, while ensuring its sealing functions, it prevents the "O"-ring from penetrating between the piston rod and the ring. The sleeve *J* has at its lower end a flange *K*, through which a threaded washer *L* rigidly secures the whole device. A modified design with the parts secured to the piston instead of the cylinder is also shown in the specification.—*March* 12, 1952.

STEAM GENERATORS

667,452. May 19, 1950.—STEAM GENERATORS, Fraser and Fraser, Ltd., of Bromley-by-Bow, London, E.3, and Andrew Rankine Angus, of the same address.

According to the invention, rows of auxiliary water circulating tubes are fitted within the shell adjacent these parts and connect the tube headers with the water space of the steam and water drum.



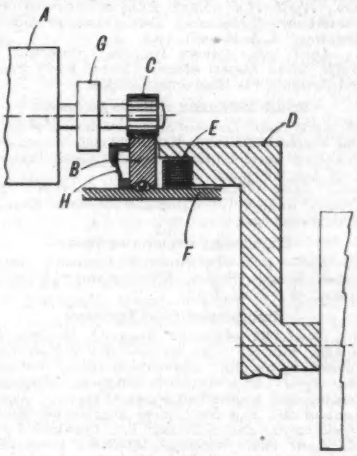
No. 667,452

The drawing shows a sectional side-elevation of the steam generator. Rows of auxiliary water circulating tubes *A* and *B* are fitted adjacent the upper shell parts *C* and *D*. There is a double row *A* and a double row *B*. The tubes *A* connect the front headers *E* with the water space of the drum and the tubes *B* connect the water space of the drum with the back headers *F*. Thus, the tubes *A* constitute upward water circulating tubes auxiliary to the main upward circulating pipe *G*, and the tubes B constitute downward water circulating pipes auxiliary to the main downward circulating pipe *H*. The tubes *A* tend to separate the hot water from the steam and to carry the hot water from the front upper headers to the drum, leaving more space via the main upward circulating pipe for the release of the steam bubbles direct to the steam space of the drum and thus yielding drier steam. The tubes *B* ensure a better flooding of the back lower headers, in that they supplement the area of the main downward circulating pipe, so reducing the possibility of water shortage in, and consequent overheating of, the tube nests. Moreover the tubes together reduce heat loss through the parts *C* and *D* of the shell, which need no longer be so expensively insulated as in the past. A baffle in the form of a trough or tray in the drum separates the first deposit or temporary hardness from the feedwater that enters the drum.—*February* 27, 1952.

INTERNAL COMBUSTION ENGINES

667,882. March 7, 1950.—ENGINE STARTER DEVICES, Societe Anonyme Andre Citroen, 117–167, Quai de Javel, Paris, XV, France.

As illustrated, a starter *A* is in engagement with a ring *B* through a pinion *C*, the ring and the pinion being permanently in mesh. The ring is coaxial to the engine flywheel *D*, which has adjacent to its periphery a groove in which is a circular magnetic winding *E*. The winding is mounted on a stationary drum *F*, which supports the toothed ring *B* through the intermediary of



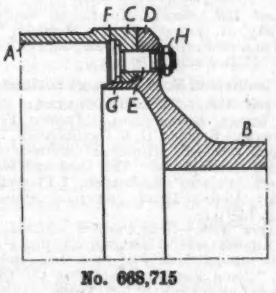
No. 667,882

balls or rollers in a groove which forms a housing for the balls, and provides for axial displacement. A free-wheel device *G* is provided and a return spring *H* keeps the ring spaced apart from the engine flywheel. In operation, when a current is passed through the winding the ring is attracted and is pressed against the flywheel so as to form a solid block with it. At the same time current is supplied to the starter, which drives the whole assembly through the pinion. In order to disconnect the starter it is only necessary to interrupt the current in the starter and in the winding. The ring then moves away from the flywheel and returns to the inoperative position.—*March* 12. 1952.

SHAFT COUPLINGS

668,715. July 17, 1950.—SHAFT COUPLINGS, Svenska Turbinfabriks Aktiebolaget Ljungstrom, of Finspong, Sweden. (*Inventor: Ake Nils Baltzar Jarlborg.*)

In the drawing an axial section of a flange coupling is shown. The two shafts are indicated at



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A and *B*, the coupling flange *C* of the tubular shaft *A* is directed inwards, whilst that of the other similar shaft *D* is directed outwards. The flanges are drilled for interconnecting *E* bolts. The bolt

heads are substantially of oblong shape. While the shafts are separated the bolts are passed through the apertures of the flange *C*, adjacent to which the tubular shaft is provided with an annular recess *F*, in which the bolts are rotated to lock them axially relatively to the flange. The flange *D* of the other shaft may now be slipped over the bolts into contact with the flange *C*. The shaft *B* has an additional flange *G* projecting beyond the heads of the bolts. The transverse face of the head of the bolt presents a radius of curvature corresponding to that of the flange *G* and fits into it so as to prevent rotation of the bolts in the operative position. Thus the bolts are locked against axial displacement as well as against rotation relative to the shaft and the flanges may be forced against each other by tightening nuts *H*. Instead of a common annular recess *F* in the tubular shaft for receiving the heads of the bolts, individual recesses may be used.—*March* 19, 1952.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Supervising Electrical Engineers

Wed., April 16th.—MANCHESTER BRANCH: Engineers' Club, Albert Square, Manchester, Open Discussion, 7.30 p.m.

Thurs., April 17th.—KENT BRANCH: County Hotel, Canterbury, "Electrical Precautions in Operating Theatres," A. A. Mansell, 8 p.m.

Fri., April 18th.—CREWE BRANCH: Copeland Arms Hotel, Glebe Street, Stoke, "Motor Fault Locating and Rewinds," D. Bosworth, 7.30 p.m.

British Institution of Radio Engineers

Wed., April 16th.—LONDON SECTION: School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, W.C.1, "Current Radio Interference Problems," E. M. Lee, 6.30 p.m.

Thurs., April 17th.—S. MIDLANDS SECTION: Public Library, Rugby, "Acoustics and the Radio Engineer," E. G. Richardson, 7.15 p.m.

Illuminating Engineering Society

Fri., April 18th.—BIRMINGHAM CENTRE: Imperial Hotel, Temple Street, Birmingham, "Light from Space," W. Wilson, 6 p.m.

Incorporated Plant Engineers

Mon., April 14th.—DUNDEE BRANCH: Mathers Hotel, Dundee, film on "The Manufacture of Plate Glass," followed by the film "Armourplate Glass," 7.30 p.m.

Tues., April 15th.—GLASGOW BRANCH: Engineering Centre, 351, Sauchiehall Street, Glasgow, "Development of the New Mechanical Engineering Research Laboratory at East Kilbride," T. C. Crawhall, 7 p.m.

Wed., April 16th.—WESTERN BRANCH: Grand Hotel, Bristol, "Industrial Fire Protection," C. Gotsell, 7.15 p.m.

Thurs., April 17th.—LIVERPOOL AND N. WALES BRANCH: Radiant House, Bold Street, Liverpool, address by the Chairman, W. H. Price, 7.15 p.m.

Institute of Economic Engineering

Fri., April 18th.—The George Hotel, Church Lane, Kingsbury, London, N.W.9, "The F.A.C.T.S. System," J. Philip, 7 p.m.——Engineers' Club, Albert Square, Manchester, "The Measurement of Productivity," P. D. Vincent, 7 p.m.——The Greyhound Hotel, Croydon, "Pre-Production Planning," J. Bailey, 7.30 p.m.

Institute of Industrial Supervisors

Wed., April 16th.—S.E. LONDON SECTION: The Polytechnic, Woolwich, S.E.18. "Joint Consultation," R. A. Miles, 6.30 p.m.

Thurs., April 17th.—BRISTOL SECTION: Grand Hotel, Bristol, Members' Discussion and Case Problem Night, 7.30 p.m.——COVENTRY SECTION: Craven Arms Hotel, High Street, Coventry, Foremen's Forum, Members' Discussion Night, 7.30 p.m.

Institute of Marine Engineers

Thurs., April 17th.—JUNIOR SECTION: 85, Minories, E.C.3, Discussion, "The Value of Technical Qualifications to the Marine Engineer Apprentice," 7 p.m.

Institute of Metals

Fri., April 18th.—SHEFFIELD LOCAL SECTION: The University, St. George's Square, Sheffield, "Corrosion of Iron and its Prevention by Deposits of Non-Ferrous Metals," U. R. Evans, 6.30 p.m.

Institute of Road Transport Engineers

Tues., April 15th.—MIDLANDS CENTRE: Crown Inn, Broad Street, Birmingham, "Chassis Frame Construction and Repair," C. F. Cunningham, 7.30 p.m.

Wed., April 16th.—E. MIDLANDS CENTRE: Mechanics' Institute, Nottingham, "The Care and Maintenance of Diesel Engines," S. Parrish, 7.30 p.m.——N.W. CENTRE: Adelphi Hotel, Liverpool, Annual General Meeting, 7.30 p.m.

Thurs., April 17th.—N.E. CENTRE: Hotel Metropole, Leeds, Annual General Meeting, 7.30 p.m.——LONDON CENTRE: Royal Society of Arts, John Adam Street, W.C.1, "Some Factors Influencing the Choice of a Crankcase Lubricating Oil," M. Towle.

Institute of Welding

Thurs., April 17th.—N. LONDON BRANCH: Polytechnic Institute, Regent Street, W.1, Annual General Meeting, 7.30 p.m.

Institution of Chemical Engineers

Fri., April 18th.—LONDON GRADUATES' AND STUDENTS' SECTION: Caxton Hall, Westminster, S.W.1, "The Fluid Catalytic Cracking Process," J. G. Lucas, 6.30 p.m.

Institution of Electrical Engineers

Thurs., April 17th.—UTILISATION SECTION: Savoy Place, London, W.C.2, "Equipment of Battery-Electric Vehicles," W. D. Sheers; "The Economic Basis of Battery-Electric Road-Vehicle Operation and Manufacture," H. W. Heyman, 5.30 p.m.

Institution of Locomotive Engineers

Wed., April 16th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1, "The Fell Diesel Mechanical Locomotive," L. F. R. Fell, 5.30 p.m.

Institution of Mechanical Engineers

Thurs., April 17th.—MIDLAND BRANCH: James Watt Memorial Institute, Great Charles Street, Birmingham, Discussion on the Anglo-American Council's Productivity Report on Welding, 6 p.m.——N.W. BRANCH: Engineers' Club, Albert Square, Manchester, "Steam Piping for High Pressures and High Temperatures," R. W. Bailey, 6.45 p.m.

Fri., April 18th.—Storey's Gate, St. James's Park, London, S.W.1, "Cavitation Mechanics and its relation to the Design of Hydraulic Equipment," Robert T. Knapp, 5.30 p.m.——N.E. BRANCH, GRADUATES' SECTION: Northern Gas Board Showrooms, Grainger Street, Newcastle upon Tyne, "Coal Handling Facilities on the North Bank of the Tyne," G. B. Marriott, 7 p.m.

Sat., April 19th.—E. MIDLANDS BRANCH: Visit to Peterborough Generating Station of the British Electricity Authority, 2 p.m.——The Museum, Priestgate, Peterborough, "Common Errors in Engineering Design and Practice," B. P. Cooper, 4 p.m.——N.W. BRANCH, GRADUATES' SECTION: Engineers' Club, Albert Square, Manchester, Annual General Meeting, "The Pneumatic Handling of Materials," P. W. Rowland, 2.30 p.m.

Institution of Structural Engineers

Thurs., April 17th.—SCOTTISH BRANCH: Ca'doro Restaurant, Union Street, Glasgow, Annual General Meeting, 6 p.m.

Iron and Steel Institute

Thurs., April 17th.—IRON AND STEEL ENGINEERS' GROUP: 4, Grosvenor Gardens, London, S.W.1, "Supply and Use of Hydraulic Power at Appleby-Frodingham," L. N. Lloyd, 10.30 a.m.; "Pump Design and Applications in Iron and Steel Works," C. G. Evans and P. L. Fairfield, 2 p.m.

Junior Institution of Engineers

Fri., April 18th.—39, Victoria Street, London, S.W.1, "Some Modern Submersible Pumping Applications," W. L. Gardiner, followed by a film, 6.30 p.m.

Liverpool Metallurgical Society

Fri., April 18th.—Electricity Service Centre, Whitechapel, Liverpool, Annual General Meeting, Presentation of Prize Winning Student Papers, 7 p.m.

North-East Coast Institution of Engineers and Shipbuilders

Fri., April 18th.—Mining Institute, Newcastle upon Tyne, "A Study of the Cause of Some Rudder Failures," T. W. Bunyan, 6.15 p.m.

Old Centralians

Thurs., April 17th.—Chez Auguste Restaurant, 47, Frith Street, London, W.1, "Swiss Industry," Rt. Hon. the Earl of Verulam," 12.55 p.m.

Royal Institution of Chartered Surveyors

Wed., April 16th.—12, Great George Street, London, S.W.1, Quantity Surveyors' General Meeting, Discussion on "Can the Standard Method of Measurement be Improved?" opened by P. T. Walters, A. Prichard and E. S. Chalkley, 6 p.m.

Royal Statistical Society

Wed., April 16th.—N.E. GROUP: 18, Louvain Place, Newcastle upon Tyne, Annual General Meeting, "Significance Tests in Action," J. M. Runcie, 7 p.m.

Society of Chemical Industry

Thurs., April 17th.—ROAD AND BUILDING MATERIALS GROUP: Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1, Conference on the Proceedings of the Building Research Congress, 6 p.m.

Launches and Trial Trips

TYNEFIELD, oil tanker; built by R. and W. Hawthorn, Leslie and Co., Ltd., for Hunting and Son, Ltd.; length overall 557ft, breadth moulded 70ft, depth moulded 39ft 6in, deadweight 18,000 tons; Hawthorn-Doxford oil engine, six cylinders, 725mm diameter by 2250mm combined stroke, 7600 b.h.p. at 114 r.p.m.; two cylindrical boilers. Launch, March 25th.

SHELLPHALTE, bitumen tanker; built by John Crown and Sons, Ltd., for the Shell Petroleum Company, Ltd.; length between perpendiculars 315ft, breadth moulded 46ft, depth moulded 19ft 6in, deadweight 3300 tons, draught loaded 16ft 11in; one triple-expansion reciprocating engine and two Scotch boilers, supplied by Smith's Dock Company, Ltd., service speed 11 knots. Launch, March 26th.

GYLFI, trawler; built by the Goole Shipbuilding and Repairing Company, Ltd., for the Icelandic Government; length 185ft, breadth 30ft 6in, depth moulded 16ft; Ruston and Hornsby diesel engine; six cylinders, 1450 b.h.p., speed 13½ knots. Trial, March 29th.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24, Victoria Street, London, S.W.1.

STEEL TUBES FOR MECHANICAL, STRUCTURAL AND GENERAL ENGINEERING PURPOSES

No. 1775 : 1951. This new standard is the third of a series for steel tubes for general engineering purposes, the other two being B.S. 980, "Steel Tubes for Automobile Purposes," and B.S. 1717, "Steel Tubes for Cycle and Motor-Cycle Purposes." The standard covers plain carbon steel tubes not exceeding 16in outside diameter, of the following kinds:—Hot finished welded (referred to as type HFW); hot finished seamless (referred to as type HFS); cold-drawn seamless (referred to as type CDS); electric resistance butt-welded (referred to as type ERW); cold-drawn electric resistance butt-welded (referred to as type CEW); and oxy-acetylene butt-welded (referred to as type OAW).

Tubes of types HFW, HFS, CDS and OAW are specified in four grades, viz., 11, 13, 15 and 20, the numbers indicating the minimum yield strength. Tubes of type ERW are similarly specified in Grades 11, 15 and 20, while those of type CEW are specified in Grades 11, 15, 24 and 28. Part One includes a number of general clauses applicable to all types of tubes, dealing with such matters as material, straightness, lengths, galvanising, methods of test and inspection. Each type of tube is then dealt with in detail in a separate section, which includes such items as tolerances and mechanical properties. At the end of the standard are tables of standard sizes of hot-finished welded and hot-finished seamless tubes. A further table gives the properties of the tabulated sizes. Price 3s. post free

DIMENSIONS OF TOROIDAL SEALING RINGS

No. 1806 : 1951. This standard, which was prepared at the request of the Ministry of Defence, applies to the dimensions of toroidal sealing rings, sometimes referred to as "O" seals, which are used as packings for reciprocating mechanisms and as gaskets for static purposes for light and medium general engineering applications. These sealing rings are not intended for use at pressures in excess of 1500 lb per square inch.

For use as packings on reciprocating mechanisms seventy-three sizes are specified in the range of ¼in to 8in and for static purposes ninety-six sizes ranging from ⅛in to 15¼in. This latter range includes the seventy-three sizes intended for reciprocating mechanisms.

Recommendations are also included for the recesses into which these rings are fitted, but the standard emphasises the necessity for close collaboration between the designer and the manufacturer of sealing rings to ensure satisfactory operation and service. Price 2s. 6d. post free.

GEARS FOR TURBINES AND SIMILAR DRIVES.—PART 1: ACCURACY

No. 1807, Part 1 : 1952. This standard has been prepared by the Institution as a development of the work done in the preparation of B.S. 1498, "Gear Hobbing Machines for Toroidal and Similar Drives." It applies to the accuracy requirements of high grade gears used in the drives for turbine and similar plant, but it does not at present cover tooth form or gear loading. It includes three classes of gears, of which Class A1 and Class A2 are generally appropriate for pitch line speeds in excess of 10,000ft per minute, or where any other factor demands the highest grade. The standards of accuracy laid down for Class B would generally be appropriate for lower pitch line speeds.

The specification deals with the nomenclature of double reduction gear trains and the accuracy of reference surfaces on the blanks. A section relating to wheels and pinions deals comprehensively with the permissible errors for undulations, transverse pitch, axial pitch, tooth thickness and backlash. Accuracy of assembly covers roundness, parallelism and coaxiality of journals, journal and bearing assembly, balancing and meshing.

We are informed that work is proceeding on the preparation of Part 2 of the standard, which deals with tooth form and gear loading. Price 3s. 6d., post free.

METHOD FOR THE DETERMINATION OF MANGANESE IN IRON AND STEEL

No. 1121 : Pt. 23 : 1951. The principle of the method detailed in this new standard is solution in phosphoric-sulphuric acid and nitric acid, conversion of the manganese to the permanganic state by boiling with potassium periodate, and finishing the determination absorptiometrically.

Price 1s. post free.